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INDUSTRIAL MANAGEMENT

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A Revision of

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To

Lois
Josephine
Gale

PREFACE

This volume is a textbook for the student of today who is preparing for the problems of tomorrow. It is true that industrial management has reached a state of maturity where fundamental thoughts and practices are recognized and standardized to a considerable degree. Nevertheless the subject is no more static than any other activity. In this book the authors have endeavored to make clear to students the application of basic principles both in current practices and in the new situations that arise in a dynamic society.

The foundation of this book was laid in the earlier text, "Industrial Engineering and Factory Management," and the general content and organization of that work, which satisfactorily met the test of successful teaching of the subject in many schools and under varying circumstances, have been retained in this edition. Since that volume first appeared, however, management in our productive enterprises has outgrown the emphasis upon the technical and labor problems with which it was largely concerned in early years, and has come to recognize the importance of the relations existing between industry and society as a whole. The idea of service to the community is much more in the foreground than formerly, and in this edition more emphasis is placed upon this aspect of management in addition to full attention to the means by which such service may practically be made most effective.

With this end in view the first two chapters show the contacts which an industrial company has with the public, including its stockholders and customers. The next two chapters give an historical sketch of industrial and managerial progress. Three chapters on the organization of the company follow—organization of ownership and organization for management. The next nine chapters treat the plant—questions concerning its location, construction and equipment for efficient operation. After a chapter on product standardization and simplification nine chapters are devoted to relations with employees. The last seven chapters describe control devices that aid management in eliminating waste and coordinating the activities of the organization toward its major objective.

This book is intended to be a textbook for students of organization and management and is designed to precede specialized training in any management field. Although its theme is management in the manufacturing industries—where it was first given the scientific approach—the ideas and practices described are fundamental to any type of business

endeavor. That they can be so utilized with only slight modification has been amply demonstrated.

The material has been largely drawn from practice, supplemented by contributions from theory and research. There has been a definite endeavor to clothe the abstract principles with both facts and explanation sufficient to show clearly how each principle applies and to bring students into close contact with actual operating detail. A wide range of case applications is accordingly a feature of the volume. The cases are drawn from small institutions as well as large, and each of them is definitely tied in with the principle it illustrates. They are supplemented by a large number of pictures and diagrams.

Use of the basic text material in many schools and colleges has yielded valuable test experience, and the fruits of this have been incorporated in this edition.

Though primarily designed as a text, it is believed that the volume will be found useful by industrial executives because of the analytical and definitely informative treatment which is followed, and because it assembles in convenient form many details of practice which they need to have at hand for reference.

In the preparation of the manuscript the authors have received constant encouragement and aid, over a period of several years, both from their colleagues in the University of Illinois and from practicing engineers, industrial executives, and other friends. They desire here to express their gratitude to the many who have thus generously contributed their time, information and counsel.

Arthur G. Anderson
Merten J. Mandeville
John M. Anderson

Urbana, Illinois
June 1, 1942

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INDUSTRIAL MANAGEMENT

CHAPTER 1

PUBLIC RELATIONS

Relation of Business to the Community.—Many business men of a past generation carried on their respective enterprises without sufficient regard for the interests of employees, the community, or the public at large. The effect of such policies was to create antagonism to business which manifested itself in radical labor activities, negative community attitudes, and tax and social legislation. Those business leaders who administered wisely and well were also engulfed by these forces. In a democracy private business is dependent upon public goodwill, and the day of wholly free enterprise is gone. "Every business exists successfully only in the measure it recognizes its responsibility to the public, its place in democratic society." [1] If the people's interests are not served there is a hazard not only to free competitive enterprise, but to our form of government. "American business is the institution that accepts responsibility for the civic, social, and economic well-being of our people." [2] The new role of industry is summarized for each business man as follows:

You must demonstrate your own assumption of social responsibility. You must provide and dispense goods and services in a way that wins public approval.

Your manner of providing them must promote social and economic progress.

Every policy, no matter what department of your business it is to govern, must be formed and carried out in relation to its effect on all elements of your public—your workers, your customers, your investors, your suppliers, your neighbors, your competitors, and your government.

You must make sure that all conditions, within your company and without, are the best that you can make them to contribute to the welfare of all the people affected.

You must, as a duty to yourself and to your public, see to it that the public is made aware of the social and economic services you are giving.

You must at all times emphasize the human side of your company.[3]

---

[1] Statement by Doctor David Kinley, President-emeritus, University of Illinois.
[2] Public Relations for Business, by Milton Wright, p. 68.
[3] *Ibid.*, p. 69.

The Need for Public Relations.—Within two generations the United States changed from an agricultural to an industrial nation. Nearly 40 million people came to depend directly upon earnings from productive enterprises. In this period the prosperity and living standards of our rank and file citizens became the envy of the world. Notwithstanding, however, the depression years following 1930 brought severe attacks upon our business and industrial organization. The fact that economic distress was world wide, and occasioned in large part by the chaos and interrupted trade relationships due to wars, was ignored or not appreciated. Surveys by the National Association of Manufacturers disclosed that in the depths of the depression 80 out of 100 people believed that industry had failed in its social and economic responsibilities. "In the confusion of fears and resentments, they seem to have concluded that short-sighted and selfish business management was chiefly responsible for their misfortune." [4] This opinion was shared by men and women in all walks of life, including college and professional groups.

The Attitude of Business Men.—Business executives were slow to realize the need of overcoming the hostility to business, and of educating the public. More goods and services were being provided to consumers at less cost, and the status of the working population was being steadily improved. It seemed to them that the meaning and value of industry to America was demonstrated on every hand. With the advent of hard times, however, the public forgot the former benefits in the confusion of the existing distress. Many radical plans and unworkable panaceas received widespread acceptance merely because they were new. Business men realized that Utopia is not arrived at through destruction and scarcity of the things people need and use, but their warnings received scant attention. Thoroughly aroused, men in both big and little business are now alert to the need of winning public confidence and belief in free, competitive enterprise. They seek to educate the public in sound economic principles, and to the hazards of changing the system under which we have gained so much. They are accepting responsibility for "utilizing the savings and labor energies of the people in the interest of their prosperity and progress, if business is to find security for itself." [5]

The Nature and Scope of Public Relations.—Public relations is a philosophy of management which gives first consideration to the public interest. It is interwoven with all aspects of plant management. W. T. Holliday sums it up in this way:

[4] An editorial, *Factory Management and Maintenance*, Vol 96, No. 10.

[5] From a statement of Dr. Virgil Jordan, President of the National Industrial Conference Board.

Your public may be said to consist of these classes of persons:

Your customers	Your stockholders
Your suppliers	Your creditors
Your competitors	Your local community
Your employees	Your government

To your customer, it is your duty to give fair and equitable treatment on a basis that is profitable to both you and him.

To those who supply you with materials or equipment, it is your duty to extend the same consideration as you desire to receive from your own customers.

To your competitors you owe a duty to cooperate, within legal limits, on a basis that will assist each unit in the industry to operate under high business standards and enable the industry as a whole to serve the public economically and effectively.

To your employees you owe the adoption of a sound and well defined labor policy, suitable to the problems of your own particular company, your community, and your industry. This policy must provide for free interchange of ideas between your management and your workers on all matters that interest them mutually, must give adequate opportunity for consideration and adjustment of all complaints, must maintain good working conditions, and must give fair wages for work performed.

To your stockholders you owe the recognition that the property of your corporation represents their investments and their risks. For their benefit your business should be so conducted as to give sound service, protect the principal, and produce a fair average profit, with consideration at all times for the human factors involved in your dealings and operations and for the public interest.

To your creditors you owe the duty of preserving your credit standing and good will by fair and equitable treatment.

To the local community or communities in which you operate you owe the duty of demonstrating that your business organization is a desirable member.

To all the agencies of the government in the exercise of their legitimate functions you owe cooperation and support.[6]

Company Plans of Public Relations.—The programs of individual companies make up the general picture of public relations, and in the final analysis determine the community and national attitude toward business and industry. Joint community programs and efforts of state and national organizations aid in creating a favorable and cooperative attitude, but the company's own program must justify the expectations raised in the public mind. "If individual enterprises do not win the favorable verdict of their own personnel, the people who come in contact

[6] From an address by W. T. Holliday, President, The Standard Oil Company (Ohio), before the McGraw-Hill Public Relations Forum, Cleveland.

with the customers and the public, there would seem to be little that any avenues of publicity or advocacy could accomplish." [7] Thus public relations begin at home in adequate and successful management programs.

A noted politician has said that every name on a public payroll is good for forty votes. This thought suggests the influence which employees and stockholders of an enterprise may exercise in community affairs providing business is conducted in a manner to enlist their cooperation. Information and education appear to be the key to this situation. The following are some effective ways that have been used to interpret corporate affairs to employees, stockholders, and the public.

Very few people are familiar with the language of accountants. The usual formal statements appearing in the reports to stockholders are not designed to create a feeling of intimacy or confidence. Recently several companies have attempted to present their financial stories in a more attractive form. The trend in corporate management is to make simplified annual statements that are attractive in appearance and readily comprehended. The balance sheet of the United States Steel Corporation shown in Figure 1 is easily understandable by employees and stockholders. It is a summary of a more comprehensive statement and tells in simple language what the company owns, what it owes, and what it is worth.

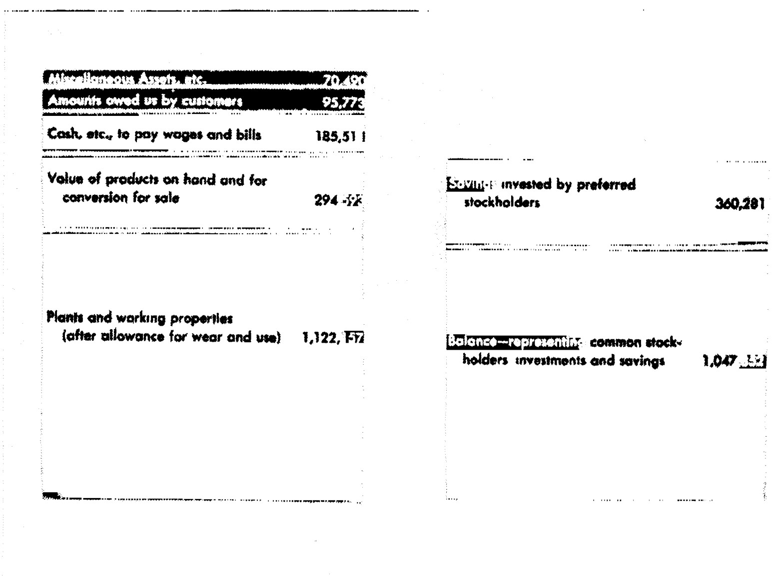

Figure 1. A Balance Sheet for Employees and Stockholders

[7] *Ibid.*

It is desirable that the employee appreciate the capital investment necessary to provide a plant in which to work, and tools, material and money with which to operate. The Caterpillar Tractor Co. presents this information as shown in Figure 2. Total capital investments per employee in manufacturing vary from about $6,000 to $20,000, depending upon the industry. Someone has to save this money and invest it.

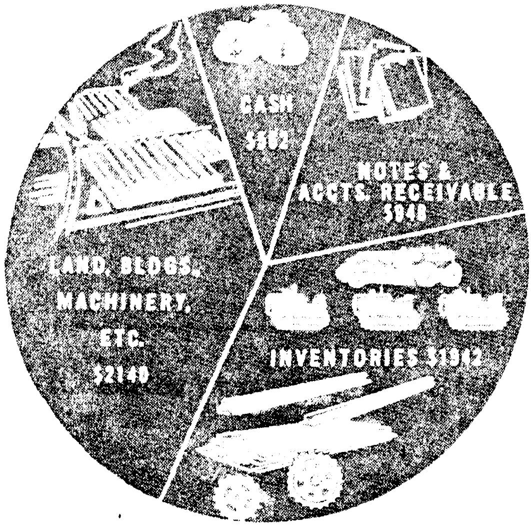

Figure 2. Chart Showing Investment Per Employee

Where the sales dollar goes is shown by the General Motors Corporation as in Figure 3. The extent to which payments are made for purchased materials, wages, executive salaries, operating expenses, depreciation, and taxes is made clear. The fact that these costs are necessarily paid before dividends can be declared is also important.

A statement of stock ownership shows the distribution of ownership and the many persons who own small amounts. Many companies personalize ownership further by describing typical investors. See Figure 4.

In order that all concerned may appreciate the relation between employment, earnings, and sales, United States Steel presents its profit and loss statement as shown in Figure 5. In the larger plants, particularly, employees may fail to appreciate the keen competition for business, and the fact that products which the consumer chooses to buy provide the only source of money for payrolls.

Other pertinent information which can be made available includes

Figure 3. Where the Sales Dollar Goes

The illustration above shows how the average dollar received from the sale of General Motors Corporation products was used. This money provides funds for the payment of all bills and for payrolls. By far the largest part (88% last year) of the earnings of the business, out of which stockholders are paid dividends, also comes from these sales. In addition, General Motors receives income as a return on its investments in companies not wholly owned.

MATERIALS AND SUPPLIES,

including freight and related expenses, absorbed almost half—48$\frac{3}{10}$ cents—of the sales dollar. Much of the money General Motors spends for materials and supplies means wages in the pockets of suppliers' employes and others in communities throughout the nation.

EMPLOYES

receive the second largest share of the sales dollar. Last year total compensation of employes, except executive management pay, accounted for 27$\frac{1}{10}$ cents out of each sales dollar.

EXECUTIVE MANAGEMENT PAY

amounted to ½ of one cent for each dollar received from sales. This comprises total compensation of the 184 executives in this group, which includes the chief executives of the Corporation and its divisions, and the executive in charge of each of the plants throughout the country.

TAXES

paid to the Federal government, to states and to local communities took 11$\frac{2}{5}$ cents out of each sales dollar. Tax costs are definitely a major item in the total cost of doing business.

PLANTS AND EQUIPMENT

wear out or become obsolete. Each year money is set aside so that the funds will be available as plants and equipment need to be replaced. The amount set aside last year for this purpose and for special contingencies came to 3$\frac{3}{10}$ cents per sales dollar.

STOCKHOLDERS

—nearly 400,000 of them—were paid dividends, as a return on their invested savings, amounting to 8$\frac{1}{5}$ cents for each dollar of sales.

The balance remaining—1$\frac{1}{5}$ cents—was left in the business. This sound practice strengthens the business, enabling it to assume new responsibilities, and forms the basis of enlarged future opportunities for all connected with it.

(1) sales and profit record of the company by years; (2) amount of taxes paid, recent increases, and relation to dividends and wages; (3) employment by years; (4) wage trends; (5) money spent for research; and (6) money used in plant development. The General Motors Corpo-

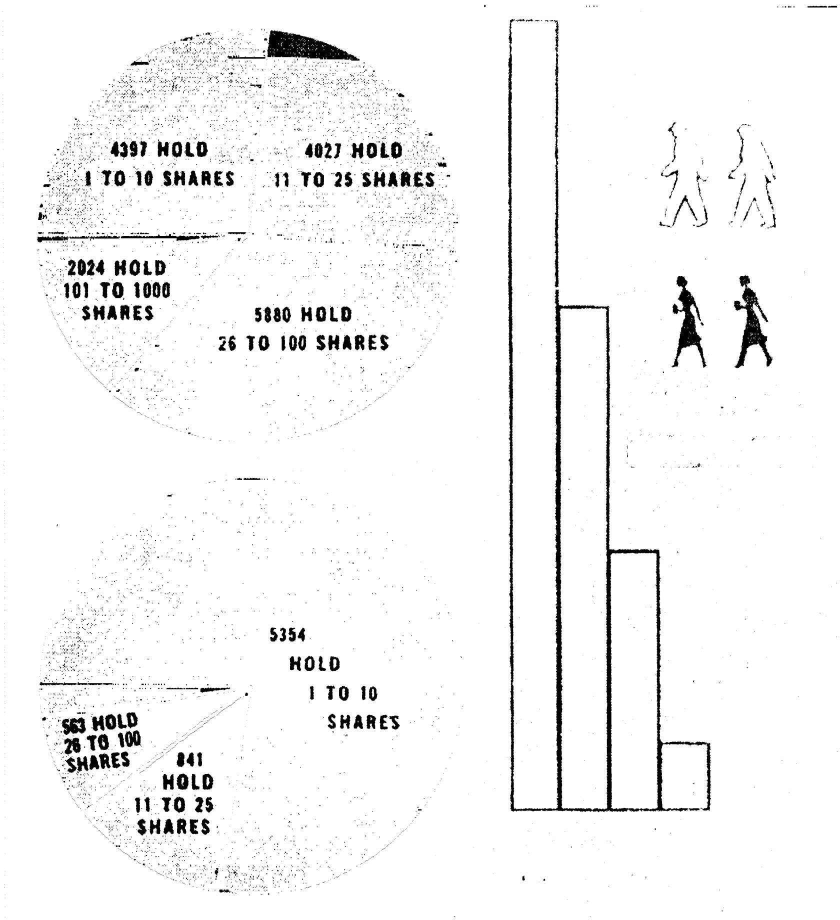

Figure 4. Chart Showing Stock Ownership by Years

ration reports to its stockholders and other interested persons that the tax bill of the corporation for definitely ascertainable taxes was equivalent to $875 per employee in 1940 as compared with $334 for the year 1935. This amounted to $42 per $100 of payroll in the United States. The effect of cost of government upon wages, dividends, and prices is obvious and will influence public opinion.

HOW U. S. STEEL EARNED ITS LIVING IN 1941

	Amount Million $	$ Amt. Per Worker
PRODUCTS & SERVICES SOLD		
(including $3 million from miscellaneous other sources)	1,623	5,336
It disposed of this sum as follows:		
PRODUCTS & SERVICES BOUGHT FROM OTHERS	609	2,000
TAXES — LOCAL, STATE & FEDERAL	191	629
WEAR & USAGE OF FACILITIES	96	315
INTEREST ON BORROWED MONEY	6	20
Sum of these items	902	2,964
Balance remaining	721	2,372
It disposed of this balance as follows:		
WAGES, SALARIES & PENSIONS FOR WORKERS	605	1,990
DIVIDENDS PAID FOR USE OF FACILITIES	60	197
RETAINED FOR FUTURE NEEDS	56	185
Sum of these items	721	2,372

This is a rearranged approximate statement of U. S. Steel's financial activities

Figure 5. Condensed and Rearranged Profit and Loss Statement

Community interest may be fostered by open house programs. Too often business men fail to realize that even though products manufactured are not used in the community, its people have an interest in local plants because their welfare is dependent upon them. Then again, families and friends are interested in the work situation of those employed, and seek understanding and enlightenment with respect to it. Workers enjoy having friends and neighbors see what they do. Given an opportunity and correct information, communities take pride in and show

loyalty toward local enterprises. Open house programs tend to personalize business and make it neighborly.

Each company should be mindful of the community situation with respect to those factors which make for better living. An environment which contributes to a wholesome and adequate family life and opportunity is a responsibility of community leadership. In recent years special emphasis has been placed upon providing better housing, more extensive parks, and recreational areas.

Having placed its own house in order with management practices which meet the test of employee, customer, stockholder, and community approval, the next step is cooperation with other enterprises in the ways to be suggested.

Community Programs of Public Relations.—"Management's public relations problem is largely a community problem. It is a matter of both public interest and self-interest for management to reach a balance of harmony with its employees, its stockholders, its customers (many of whom are employees and stockholders), and the people of the community . . . Management must be active in civic and public affairs as an indication of its own good citizenship . . . It is just plain common sense as well as good business for management to take an active interest in the schools, churches, health, housing, tax rates, bonded indebtedness, and general welfare of the community. If the community fails to carry out its social and economic obligations, then industry must shoulder an extra burden. Management must work actively to maintain good community conditions and improve unfavorable ones . . . All these things bear mutually upon the community's welfare, the welfare of the industry within the community, and the ultimate success of the two." [8]

Effective personal relationships need to be established among community leaders in order that the aims and objects of business and industrial activities may be understood. One city organization of business and industrial leaders arranges for various groups to be represented at all meetings where such matters are discussed. These include ministers, educators, reporters, and representatives of labor groups, women's clubs, welfare organizations, and the like.

THE EVANSVILLE PROGRAM OF PUBLIC RELATIONS.—The business men of Evansville, Indiana, have carried on a public relations campaign with success. It was recognized that "as manufacturers we had done a pretty successful job of selling our products to the public. We had done

[8] Comment by T. G. Graham, Vice President, the B. F. Goodrich Company, *Factory Management and Maintenance*, Vol. 97, No. 9, p. 46.

a miserable job, or no job at all, of selling the plans, principles, and policies that make these products of ours possible. It became increasingly clear that the wage earners and general public of our community had not been sold, and that unless the manufacturers took over the job of selling they would never get the facts. The outgrowth was the

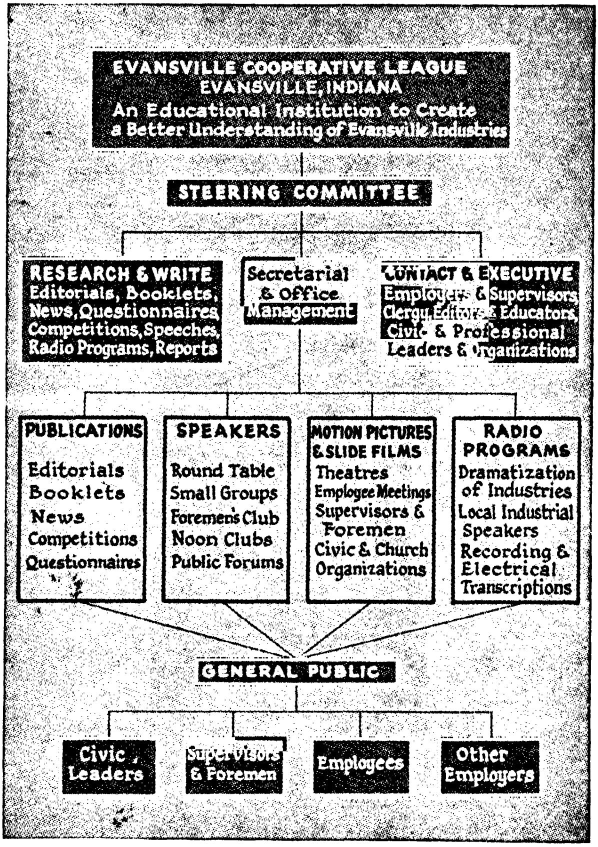

Figure 6. Organization and Activities of Evansville Cooperative League

Evansville Cooperative League."[9] Its organization and activities are pictured in Figure 6.

Special emphasis was given to improving basic conditions of employment and programs of personnel relations in individual plants. "By our full-page advertisements in Sunday papers, our letter and poster and

[9] "Evansville Does a Public Relations Job," by Thomas J. Morton, Jr., *Factory Management and Maintenance.* Vol. 96, No. 12.

essay contests, our outside and League member speakers—by our entire program we seem to have convinced our townspeople that we are sincere, that we are frank, that we genuinely wish to be fair. Moreover, few literate people in this community fail to comprehend that consumers really pay wages, that taxes are paid by everybody including the man with no property and small income, that the important point is what wages will buy rather than how many dollars the envelope contains, that prosperity for each and all comes out of production and not out of the employer's pants pocket." [10]

The program has brought enlightenment to the workers of the community, the women, professional men, ministers, teachers, and others, about industry and what it means to the community; and educated them with respect to the economics of human relations and legislation. Unsound ideas from whatever source will be less likely to receive support in the future.

Business and Industrial Associations.—Business and industrial enterprises have sought to benefit by membership or representation in various organizations. These include local chambers of commerce, trade associations comprising those engaged in the same line of business, state chambers of commerce, state manufacturers' associations, the United States Chamber of Commerce, National Manufacturers' Association, and the National Industrial Conference Board. These organizations provide a medium for the interchange of experience and ideas, the formulation of general policies for research, and for influencing public opinion and legislative trends. They have been an important factor in keeping the thousands of smaller companies abreast of the times. In recent years they have evolved programs designed to inform and educate the public with regard to the aims and objectives of business and the benefits which accrue from modern management practice. These take the form of radio programs, publications, reports of research, convention programs, news releases, formulation of codes of management policy, etc.

Unfortunately, "the public has been taught to be suspicious of explanations that come from business. The very circumstances and propaganda that have made it necessary to explain business have also made it difficult for business to do the explaining . . . There is no problem about preparing explanations of American business. The facts are available. When they are assembled, arranged, and weighed, they are favorable to business. The real problem is to find some way to assure the public that the facts are credible." [11]

[10] *Ibid.*
[11] Public Relations for Business, by Milton Wright, p. 58.

Basic data about industry are available in publications of the National Industrial Conference Board, the McGraw-Hill Publishing Company, and elsewhere. They are based upon facts and figures derived from the United States Bureau of the Census, the United States Department of Labor, and similar sources. Some examples of the information available which is helpful in giving a true picture of the influence of industry upon American life are presented as follows: [12]

1. In little more than 100 years (1820 to 1937), while population has increased 13½ times, jobs in industry have increased 48 times. Jobs in agriculture have increased 5½ times.
2. In 1937 there were 3 times as many factory jobs as in 1879. Wage earners received nearly 11 times as many dollars.
3. During the period 1879 to 1937, 16 new industries created more than a million new jobs in the making of equipment and products that we cannot now imagine living without. A total of more than 2,000,000 new jobs were created in this period.
4. National wealth per person was $1,450 in 1900, $2,100 in 1934. National income in 1899 was $209; in 1934 it was $391 ($539 in 1937; $644 in 1929).
5. While wealth and income per person were increasing, wages went up more rapidly than prices, so that employees' incomes purchased more. The incomes rose faster than the cost of living.
6. In 1937, 20,000,000 out of 30,000,000 American families owned cars; 24,000,000 American families owned radios; 64,000,000 life insurance policies were held by American people; and there were 44,226,178 savings accounts.
7. During the period 1933–1934 the average profit in the manufacturing industries was equal to 4.2¢ for each sales dollar, or 4.3½¢ for each invested dollar.
8. During the period 1923–1934, factories paid out for federal, state, and local taxes from 1.7½¢ to 2.6¢ of each sales dollar. Taxes were as high as 12.9¢ per payroll dollar and 71¢ per dividend dollar.
9. During the period 1929–1935, 78.2 per cent of the money taken in by the manufacturing industries went for materials, fuel, transportation, replacement, interest, rent, taxes. The remainder, plus a considerable amount taken from surplus, was expended for wages and salaries, company officers' salaries, and dividends. Of each dollar so spent 72¢ went for wages and salaries, 8¢ for company officers' salaries, 18.5¢ for dividends, and during one year only, 7.8¢ to surplus.

A report prepared by *Business Week* is designed to give a picture of the use of money by American industry.[13]

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[12] "Public Relations for Industry," *Factory Management and Maintenance*, Vol. 96, No. 10.

[13] "Public Relations for Industry," a report to business executives by *Business Week*.

A Report

To employees, stockholders, and the general public on how all American corporations earn their living; how they disposed of more than a trillion dollars in the ten-year period from January 1, 1928, through December 31, 1937.

Received from public for goods and services			$1,185,955,000,000
Other income			24,067,000,000
Giving business a total to work with of			$1,210,022,000,000

Which was disposed of as follows:

	% of gross	% distribution of this balance	
A. Items over which management has no direct control:		....	....
Materials, and services purchased from others	66.11	....	$799,913,000,000
Wear and Tear—depreciation and depletion	3.31	....	40,018,000,000
Taxes—Federal, state, local	2.56	....	20,983,000,000
B. Leaving a balance (28.02% of gross) for workers, management, and stock and bond holders (over which management has some direct control)	....		339,108,000,000
Workers received in salaries and wages	19.29	68.83	233,395,000,000
Management received for services	2.00	7.14	24,219,000,000
C. Leaving for bond and stock holders as payment for use of factories, mines, railroads, other tools and working capital	....	....	81,798,000,000
Of which Interest amounted to	3.28	11.71	39,696,000,000
Leaving for Dividends	3.45	12.32	41,798,000,000

But after paying dividends of $73,626,000,000, expenditures of corporations for all purposes—purchases from others, taxes, wages, etc.—amounted to $1,231,850,000,000. Thus, the draft on capital in the ten-year period amounted to $21,828,000,000.

In this report, compiled for the first time, *Business Week* departs from the usual accounting form used by corporations in annual reports to their stockholders—on the theory that business executives more and more are leaning toward humanized treatment of their financial affairs, so that workers, customers and the general public may readily understand what's what. The report embraces all corporate industry in the United States—mining and quarrying, manufacturing, construction, agriculture, transportation and other utilities, services, finance, wholesale and retail trade, and miscellaneous corporate activity. The data were derived from official government reports, but even so, in such a vast statistical project, undertaken here for the first time, the totals can only represent approximations. But the figures have been carefully compiled and checked, and in the opinion

of the editors of *Business Week,* give a reasonably true picture of what American business does with the money it receives from its customers for the products and services it sells. (Data: Statistics of Income; National Income; Census Reports.)

The American Iron and Steel Institute.—The activities of the American Iron and Steel Institute suggest what can be done to inform and educate the public about an industry, and thereby to bring about a change in the public attitude toward it. In former years the public knew little about the industry and what it did know was unfavorable. The steel industry is big, and hostile critics associated bigness with badness. The industry was dilatory in adopting the 8-hour day in lieu of the 12-hour shift, and this was assumed to reflect its general attitude toward labor. It did not answer the attacks of its critics or tell its story to the public. As a consequence, a considerable element of public opinion was unfavorable to the steel industry, believing that it sacrificed the general interest for the selfish interests of its owners. In 1933 the American Iron and Steel Institute began its efforts to overcome this attitude. Some of its activities include: [14]

Preparation of pamphlets.
Issuance of the publication *Steel Facts.*
Release of statements to the press.
Functioning of the institute and its statistical facilities as a source of information about the steel industry.
Distribution of an educational movie on the steel industry.

The facts presented effectively refute the assertions of most critics and reveal the steel industry as an economic agency contributing to social progress. Workers in the industry are favored by high wages and relatively steady employment. Many older workers are employed. Pension plans financed entirely by the companies are in effect. Newer products require more labor hours per ton of output. Dividends to stockholders have been nominal. Management practice in general has been of a high order. Appreciation of these and many other facts as presented month by month tends to improve the public attitude toward all industry.

Examples of concrete facts presented in this publication are as follows:

1. The effect of technology of the steel industry from 1926 to 1939 resulted in the scrapping of 173 blast furnaces, 39 steel works, and 144 finishing plants. New plants built include 14 blast

[14] Public Relations for Business, by Milton Wright, p. 92.

furnaces, 12 steel works, 42 finishing plants. Also there were improvements in existing equipment. The number of employees increased during the period.

2. Labor's share of the steel dollar increased from 35½¢ in 1929 to 40½¢ in 1938. Taxes took 5½¢ of each dollar received in 1938, almost 40% more than in 1929, when less than 4¢ of each steel dollar went for taxes.
3. An American steel worker could buy a basket of staple groceries with the wages from about 1½ hours of work. The cost to an English steel worker, 4½; a Swedish steel worker, 5; and a German steel worker, 6½. Russian steel workers had to work about 23½ hours to buy a similar basket of food, and Italian workers almost 10½ hours.
4. The United States' share of world steel output in 1884 was 26%; in 1929, 48%; in 1937, 38%; in 1938, 27%.
5. In 1938 wage-earning employees in the steel industry received more wages per ton of product than in any of the four preceding years. Productivity per man-hour of work was somewhat lower than in any year of that period except 1934.
6. Hourly earnings of wage-earning steel employees in 1937 averaged 82¢ per hour, or 28% above the average 74¢ earned by workers in all manufacturing industries.
7. In 1890 the average number of hours worked per week was 67 hours; in 1929, 55 hours; and in 1937, 37 hours. Hourly rates were 23¢, 65¢, and 82¢ respectively.
8. In 1890, 171,000 men were employed in the steel industry; in 1929, 419,500; and in 1937, 513,000. Production in 1937 was 10% below the 1929 output.
9. Nine out of ten top executives of the steel industry started at the bottom of the ladder and worked their way up.

Summary.—Public relations efforts begin at home with an adequate personnel program. With this step accomplished, a part of the program for successful community relations is also being carried out, in the influence exerted by employees, their families and friends in community affairs. This may be augmented in the ways suggested. Efforts through trade and national agencies is a further step which serves to crystallize the efforts of individuals and communities into a unified program designed to reach the public at large. The future of privately administered, competitive enterprise depends upon a right understanding and appreciation by the public of the aims and objectives of business and industry, and the economic and social gains which are being achieved.

Enlightened management is awake to the need of building friendly relations with the public at large. Modern business with its dependence upon large-scale production and widespread markets must have the confidence of its present customers, its potential customers, and its employees—in other words, the public. The selfish and secretive attitude of a previous period is a thing of the past. It has given place to a spirit of service and open dealings that was scarcely dreamed of half a century ago.

CHAPTER 2

DISTRIBUTION AND RESEARCH

The Economy of Plenty.—Scarcity was the accepted condition of economic society throughout the ancient world and in Europe during the Middle Ages. This state of affairs was relieved in some degree by the introduction of machinery in England during the 18th century, but it was left to a later time before any appreciable part of society's activities could be turned from the production of the necessities of life to the distribution of the fruits of industry. The rapid strides made in the mechanization of agriculture and in manufacturing during the last 50 to 75 years have given people the hope of overcoming this ancient scourge of scarcity and substituting in its place an economy of plenty. Today, through adherence to the principles of mass production, it is possible to produce goods in sufficient quantities and at reasonable enough prices to bring them within the reach of a very large percentage of our population. The problems of production will never be solved entirely, for the reduction of costs is an unending process, but we have sufficient knowledge of production methods and principles at present to allow us to turn our attention now to a solution of the problems of marketing.

In fact, it is necessary to increase the market for a product in order to realize the benefits that come with large-scale production. The old-time artisan who waited in his shop for a customer to give him an order to make a pair of shoes was restricted to a very small output. The modern shoe manufacturer employs specialized machines and workmanship to turn out thousands of pairs a day at a fraction of the cost per pair for the old-time cobbler, but it would be impossible for the manufacturer to do this if he did not rely on a widespread marketing organization to find customers for his product. Sales and production are closely interrelated, and the two departments must work in cooperation to achieve outstanding results.

Mass Production.—The outstanding development in recent years in man's struggle to produce sufficient goods to satisfy his ever-expanding wants is the system of manufacturing known as mass production. This method of production is an American institution which has spread to other countries, but still reaches its culmination in this country.

Although it is generally thought of as being used only in large plants, the methods employed in mass production are applicable to many small companies on only a slightly restricted scale. Small manufacturers of washing machines, stoves, and lawn mowers have used the technique successfully. "Large" is a relative term, and when it is said that this method employs a large amount of machinery or conveyors, it must be understood that this is large in relation to some other method of manufacturing. The actual investment may or may not be more depending on the size of the enterprise. However, it is true that the larger and richer companies, such as the Ford Motor Co., have been the most outstanding exponents of this type of manufacturing.

The characteristics of mass production may be summarized as follows:

A high degree of specialization in labor.

A great use of machinery, power-driven tools and handling equipment, usually of a special design.

A complete uniformity of the component parts of the product, thus making for interchangeability without the necessity of special fitting.

A low labor cost per unit of output.

An almost uninterrupted movement of the product during the course of production, with the product brought to the workers rather than the workers moving to the product.

Great attention to planning and close timing on all processes.

An interdependence between all departments of the company.

Mass Distribution.—As Bernard Lester says, "Mass distribution is the child of mass production, but in this instance the child supports the parent." [1] Since mass production operates best when there is an even flow of production, it is essential that the distributing system keep orders coming into the plant. When sales fall off, costs begin to mount due to the high overhead charges, and this may mean that large losses will be incurred. When the system is working smoothly it is relatively easy to increase production to almost any extent by adding additional units or increasing the speed of the work by adding to the labor force. As a consequence, great emphasis is placed upon sales and the selling price of the article is constantly being reduced in order to maintain an increased volume. This works to the benefit of the consumer while at the same time it gives added importance to the sales function.

[1] Applied Economics for Engineers, by Bernard Lester, p. 21.

In developing mass distribution, these factors characterize progress to date:

The selecting and establishing of sales outlets where the product will be available for purchase in a manner easy, pleasant, and satisfactory to the customer.

The creation of demand and the cultivation of customer acceptance through all the devices of sales promotion and advertising that can be conceived.

Providing a pricing policy which seeks to sell goods to the user at continually lower prices.

The mechanizing of all routine matters relating to the distribution of the product.

Providing, in most instances where the purchase involves a sizeable financial outlay for the individual user, a means of financing the purchase.[2]

Although not all industries have been able to take advantage of the economies demonstrated by mass production, the greater emphasis placed upon sales has also affected their operations to a marked extent. Increased competition for markets has spread to all lines of goods.

The Sales Problem.—The potential market and ways of reaching the market are of primary consideration to enterprisers. The manufacturer is confronted with a changing, competitive, and progressive market. Buying demands and preferences influence the qualities and characteristics of commodities and prices. This is true not only for articles like clothing and household goods purchased and used by consumers, but for capital goods, machines, and equipment used in making other products. That the situation has proved stimulating and an incentive to manufacturing ingenuity and effectiveness is evidenced by the lower prices and wider use of automobiles, electric refrigerators and household appliances, radios, and the like. While the public has recognized the great strides made in reducing manufacturing costs, it remains critical of the country's marketing structure and costs of distribution.

The Cost of Marketing.—The cost of marketing, from the manufacturer through middlemen to the consumer, may equal or exceed the cost of manufacture. For some goods marketing costs amount to 200% or 300% or more of manufacturing cost; for cosmetics as much as 700% or 800%. Some critics maintain that this marketing service does not add to the use value of products. The part that it plays in increasing use and thereby making it possible to manufacture and sell at low prices is not so apparent. The consumer is also likely to overlook the miracle of

[2] *Ibid.*, p. 22.

low production costs achieved in many instances, and judge the situation by the per cent of production costs added to give the selling price, rather than the actual number of dollars.

Some sections of the public have been critical of so much advertising and sales effort, believing that it merely diverted buying from one competitive product to another without increasing use, and that it caused people to buy unwisely. While it is doubtless true that some advertising is uneconomic, advertising in general has been instrumental in establishing a market for numerous products much more quickly than it could be done by any other means. The problem is to eliminate the wasteful advertising instead of condemning the entire system.

Another phase of the sales problem is that of administrative costs. These are not so readily analyzed and controlled as production costs. Selling effectiveness is less tangible than production effectiveness both as regards mechanism and men; while the time, place, and circumstances surrounding sales effort cannot be standardized and subjected to measurement. Nevertheless, management principles, practices, and standards are being evolved and aid in controlling the cost of marketing.

In the United States there is considerable competitive freedom and opportunity to try out various methods and ideas with respect to marketing. The fruits of this experience benefit the consumer by bringing about constructive changes. The individual enterprise must avail itself of the best current ideas and practices or be at an economic disadvantage with those interested in the same market. At the same time government regulation tends to curb unfair competitive practices or policies which are not in the public interest.

The Sales Organization.—A sales department will usually have divisions for advertising and sales promotion, and sales. Depending upon the nature and extent of the business, a service division, or one handling foreign trade, may be added.

The structure, character, and size of the sales organization depend largely upon three principal factors:

1. The product or products offered for sale. A wide variety exists in kinds of machinery and equipment which one manufacturer may build. The degree of engineering skill required in a proper selection and application of the product to the customer's needs may vary greatly, depending upon the nature of the market.

2. The market, which may vary greatly as to the size, number, and location of customers and prospective purchasers. Their buying habits and practices may also vary greatly.

3. The methods of distribution in reaching the market may vary widely, and the extent to which resale outlets are employed presents conditions vitally affecting the structure of the sales organization and its operation.[3]

Selling a Full Line.—Many salesmen sell a full line of their company's products, as in the case of hardware to retailers. Salesmen for a jobber of paper products and school supplies handle more than 1,000 products, consisting of some 15,000 items, and average 8 or 10 calls a day, sometimes 15 or 20, upon retailers, hotels, schools, printers, and others. With well-established accounts the salesman's work consists in part of replenishing stocks at periodic intervals, and sales effort is concerned with maintaining satisfactory dealer relations and in seeking new accounts, rather than with prices. Many sales organizations contacting consumers and retailers place responsibility for collections upon salesmen. The latter's first-hand knowledge of the customer is valuable to the credit manager, and the practice is an effective check upon salesmen who think too much in terms of orders.

Specialization by Products.—Another way of organizing a sales force is by lines of product. This arrangement gives the advantage of specialization, which becomes more effective as individual products increase in importance, require expert sales or technical knowledge. A disadvantage would be the increase in traveling expenses for salesmen covering the same territory. When a customer buys several lines or products from one company the idea of specialized selling may need to be modified, as too many sales contacts create confusion in the selling organization and are not welcomed by the prospect. Sales arrangements may take the form of different salesmen for different classes of buyers. One man may call upon the retail trade, another upon selected large consumer accounts, and another upon industry. Specialized selling by industries is also arranged for in some lines where technical information and trade knowledge are important.

The sales group may be organized under one executive, or under two or more assistant sales managers each responsible for a line of products, or possibly a class of buyers. Organization of sales by geographical areas proves successful in some cases. A metropolitan area may be covered by one group, regional areas by others. A company doing business nationally, or in several sections of the country, may establish regional sales headquarters. This tends to localize the company in the mind of the customer, which is desirable. When orders can be shipped from stocks in the respective areas the situation is further improved.

[3] Marketing Industrial Equipment, by Bernard Lester, p. 165.

Analysis of the Market.—"Market analysis is the study of the possible market or buying power for specific products, so conducted as to furnish definite information that will enable the manufacturer or other distributor to ascertain his possible total sales volume, and so to distribute his sales and advertising effort as to receive maximum returns at a minimum cost." [4] The data needed vary with the product, and would be quite different for consumer goods than for products used by industry.

Market Analysis for Consumer Goods.—A market analysis for consumer goods of various kinds in a given community would take into consideration the population, the class of people, occupations represented, average incomes, buying habits, competition, and other influencing factors. The sale of many staple products, such as salt, sugar, coffee, bread, and the like is determined mainly by population figures, and is not increased greatly for any length of time by sales efforts. The sale of work garments would be influenced by the occupations represented, the number engaged, and payrolls. Fresh meat sales in a wage-earning community fluctuate with prices and payrolls. The buying of furniture and household furnishings depends upon the number of new homes being established and the general level of community prosperity. Automobile registration figures for the various states provide an index of gasoline sales and of repair parts. The number of home owners suggests possible sales for oil burners or automatic coal-burning equipment. Building permits indicate possible sales for plumbing goods, light fixtures, hardware, and many other products.

The use of household electrical equipment is naturally limited to those homes where electric current is available, and is further influenced by the cost of electricity and the use of gas. Farm markets may be estimated by considering the farm population, number of farms, size of farms, crops, and livestock raised, farm incomes and other factors. Climate is an influence in the sale of many products, such as heating equipment, sporting goods, and clothing. Office furniture, filing cases, and other office equipment would be purchased mainly by those engaged in business and the professions. The number of business telephones may be a guide to this.

Analysis of the Industrial Market.—For purposes of analysis the industrial market has been classified into three types: i.e., (1) the horizontal market, (2) the vertical industry market, and (3) the vertical product market. The producer of articles used generally in manufacturing plants, such as electric motors, would be interested in the horizontal

[4] Industrial Marketing, by John H. Frederick, p. 25.

market including all industry. Manufacturers of articles used by one or several industries, such as shoe machinery and upholstery materials, would need information of the size, number, and location of plants in particular industries. If the article to be sold is used in making one of a number of products produced by an industry, the analysis will need to disclose which plants in the industry produce the product in question, and how much of it. The following factors are used as the basis of analysis of the relative importance of the manufacturing market in different areas:[5]

1. Number of manufacturing plants.
2. Number of wage earners.
3. Number of salaried employees.
4. Wages paid.
5. Salaries.
6. Rated horsepower of equipment in the plants.
7. Cost of materials used in manufacturing.
8. Value added to materials by manufacturing.
9. Value of products produced.

With regard to the use of these factors, John H. Frederick writes as follows:

> The choice of the appropriate factor or combination of factors will depend upon the product to be sold. Thus, in measuring the potential market for certain products, such as paint, the number of plants might be the important factor; whereas in the case of other products, such as lubricating oils, it may be advisable to give more weight to the rated horsepower of equipment in the plants . . . The factor that measures buying power for his particular product to the best advantage will be the factor of most significance to the manufacturer . . .
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> Measuring the Horizontal Market.—In general it may be said that the relative importance of the horizontal manufacturing market in different parts of the country is indicated by the concentration of industry in the different counties and cities, as measured by one or more of the above factors. Potential markets for products consumed in this horizontal market should be largest in those counties which have the greatest number of manufacturing plants and wage earners, and in which the cost of materials and value of products manufactured are greatest . . .
>
> Measuring the Vertical Market.—In studying the vertical market the size of plants, as well as their number and location need to be known . . . In the case of specific lines of equipment and supplies, it is

[5] "Manufacturing Market Statistics," U. S. Department of Commerce, Domestic Commerce Series No. 67.

frequently possible to determine the size of the market with a remarkable degree of accuracy, provided the distributor has among his customers a few who purchase from him exclusively. A comparison of these customers' purchases with their importance as a market, as indicated by some factor or factors, such as the number of wage earners in their employ, gives a basis for measuring the total market for the product in question for the whole country.[6]

Sources of Market Analysis Data.—Data and information for making market analyses are available to a surprising extent. A great deal of basic information is compiled by the Bureau of the Census and the Department of Commerce at Washington. Trade associations and the publishers of trade and farm papers know their fields thoroughly and are prepared to supply detailed information needed in making market surveys. Other sources include building permits, crop reports, financial journals, and reports of bureaus of business research. Several years ago the marketing counselor's staff of the McGraw-Hill Publishing Company, Inc., New York, made a study of the industrial market situation in ten selected cities. Their purpose was to secure data pertaining to each industrial plant in the respective areas, which when analyzed would provide a dependable guide for the formulation of marketing methods designed to reach industrial buyers.

Using Market Counselors.—Market counselors are available who specialize in making marketing surveys. They are used to a considerable extent in the field of consumer goods, but less in capital goods lines. For new products which are to be distributed widely, and which are not too complicated or technical, outside service may be desirable. Companies which make their own surveys believe that in ferreting out the information desired greater accuracy is achieved, and added insight and understanding are gained of the market.

Channels of Distribution.—Goods and commodities move from producers to users through one or more of several middlemen including (1) sales direct to the consumer, (2) retail stores, (3) jobbers and wholesalers, (4) industrial dealers and distributors, and (5) manufacturer's agents.

Producer to Consumer.—This simple, direct method of distribution is utilized effectively for a variety of products. Sales may be effected by means of advertising and receipt of mail orders, as evidenced by the success of the mail order companies and sellers of nursery stocks, hosiery,

[6] Industrial Marketing, by John H. Frederick, Ch. 2.

books, and the like. Door-to-door selling is carried on for articles such as vacuum cleaners, brushes, hosiery, and other articles of household use. In country areas automobile salesmen with established routes offer customers a line of 100 or more articles including spices, extracts, toilet articles, medicines, and poultry and stock feeds. These men usually purchase and resell the goods handled, but are given sales direction and assistance the same as though they were company employees. The business man is asked to buy cash registers, adding machines, and other specialty items at his place of business. Much railroad equipment is sold direct. Manufacturers tend to deal with producers as machines and equipments used increase in size, cost, or become complicated and technical. Most machine tools, however, are sold through dealers, but some are sold direct, and some builders use both channels of distribution. An obstacle to more direct selling is the demand made upon the customer's time. For this reason housewives, farmers, and business men prefer to buy as much as possible through trade channels.

Retail Store Outlets.—The use of retail outlets ordinarily separates the producer from the customer. In many instances customers also have the opportunity of choosing competitive products when making a purchase. Customer convenience is a big factor in this method of selling. Many consumer purchases are in small amounts and may include items from different industrial sources, as for example, cheese, brooms, canned goods, and flour. Purchasers are in general familiar with the goods offered through advertising or use, and special sales effort or expert sales service is ordinarily not justified. In fact, in many retail outlets the service of clerks is being minimized, and their function limited to assisting the customer to get what he wants, package the articles chosen, and make change. Advantages to the manufacturer of retail outlets are the fewer salesmen needed, the less expense in connection with customer accounts, decreased credit risk, and smaller cost of packing and shipping larger orders.

Jobbers and Wholesalers.—These agencies provide for large-scale buying and selling with resultant lower costs. They serve retailers to advantage by having available products from various producers. On many staple products profit margins are dependent upon volume sales, and the articles do not warrant any considerable expense for sales promotion. This channel is particularly economical in reaching small or scattered retail outlets. In comparison with retail stores, the advantages of fewer outlets, credits, administration costs, and of shipping costs are further increased. Not many machine tool products are marketed through jobbers or wholesalers. Groceries, hardware, and plumbing goods are

examples of products handled in this way. Manufacturers of the latter products advertise generally to the public, and through trade channels to architects, jobbers, and plumbing firms, supplying the latter groups with catalogs. Field men likewise contact these groups and seek to promote a demand upon jobber stocks for the firm's products. Direct sales of some lines may be made to municipalities, water and gas companies.

The Industrial Dealer or Distributor.—The industrial dealer or distributor handles machine tools and equipment, contractors' supplies, shop supplies, power and transmission equipment, various classes of tools, electrical supplies, heavy hardware, and other lines. He serves as a middleman between the producer and industrial consumer. He buys, stocks, and resells; he employs traveling salesmen, issues catalogs, and assumes credit risks. Close contacts are maintained with the trade, and salesmen endeavor to be helpful in connection with technical problems. Ability to make deliveries from local stocks, and to deliver small and emergency repair orders quickly attracts business.

A distributor specializing in steel products maintains ten regional stocks and offers the industrial market more than 10,000 kinds, shapes, and sizes of steel products. Bars are analyzed and tested for chemical and physical properties and heat treatment response. Data sheets and charts showing properties of the steel and results of the tests are prepared and sent with every order, large or small, as a guide to heat treatment.

The Manufacturer's Agent.—The manufacturer's agent is an individual or firm that is granted exclusive sales rights in certain areas, which may consist of a city, district, or include one or more states. He operates on a commission basis, handling the products of different manufacturers which complement each other rather than compete. "The average manufacturer's agent is distinctly in business for himself, carrying no stock of goods, however, and soliciting orders on the basis of prices and terms dictated by the manufacturer, who ships and bills orders directly to the purchasers." [7] Lines distributed through this channel include most lines handled by the industrial dealer or distributor. Manufacturers' agents may be used to supplement a sales organization, and enable the manufacturer to derive business from territory not economically accessible otherwise.

Combination of Methods.—In the effort to lower costs and to adjust marketing procedures to changes in the market, producers are continually

[7] Industrial Marketing, by John H. Frederick, p. 130.

seeking more economical and better channels of distribution. Manufacturers may sell products through regular channels under their own brands and at the same time supply other distributors with private brands. Some tire manufacturers increase production volume in this way by selling to the mail order houses. Shoe manufacturers, distributors of gasoline and oil, drug manufacturers, and others increase and stabilize sales by establishing their own retail stores as well as selling to independent retailers. A large manufacturer of soap products distributes through jobbers and at the same time seeks orders directly from retailers. In this instance a public demand has been created by advertising and sales promotion which justifies the jobber in serving small and scattered retailers not reached directly by the producer. A number of large merchandising firms own and operate mills and factories which supply in part the products they handle. In other instances plants dispose of their outputs to a single customer, who may resell through branch stores and at the same time act as a distributor to independent outlets. It is not unusual for manufacturers or distributors to use retail outlets in a community to serve small buyers, and contact the more important users by means of salesmen.

Methods Used by a Tractor Company.—The Caterpillar Tractor Co. makes Diesel engines, tractors, and road machinery. The United States and Canada are divided into four sales divisions. Distributors for tractors and road machinery are appointed, each with a specified territory. Agricultural dealers and engine dealers are also appointed. These dealers, while operating in distributors' territories, are limited to the class of users of the products that they sell. Each sales division has district representatives and engine representatives who contact their respective distributors, and dealers. As tractors are used to operate earth-moving equipment, bull-dozers, graders, scrapers, snow plows, and other equipment, there is an accompanying demand for this auxiliary equipment which is sold through the same channels. This equipment in part is supplied by a selected group of independent manufacturers, who have working agreements direct with the distributors. Close working arrangements with the Caterpillar Co. assure satisfactory designs and service. In these cases the primary need of the customer is the auxiliary equipment, the tractor merely providing the motive power.

Advertising.—Advertising is used to sell or facilitate the sale of goods and commodities. Media most used to advertise consumer goods include newspapers, magazines, mail order catalogs, the radio, window displays, and billboards. Industrial products are advertised in business papers, trade and professional magazines, and technical journals. Direct mail

advertising is also used in the form of letters and folders, catalogs are issued, and some use is made of moving pictures, exhibits, and other forms.

Much consumer goods advertising is designed to inform and convince the customer, so that little or no further sales effort is required. The consumer is educated to ask for the product. In many retail stores there is much more buying than selling. For more important purchases advertising may predispose the customer in favor of the product or article so that the salesman's task is made easier. Manufacturers of industrial products find advertising useful in the following ways: [8]

1. Advertising creates prestige for the manufacturer.
2. Advertising maintains contact with buyers between purchases.
3. Advertising helps to overcome prejudice. It must be a source of information for buyers.
4. Advertising reaches those buyers who are out of range geographically, or whom it is difficult to see.
5. Advertising aids in discovering those who are actually interested in the products advertised.
6. Advertising aids the manufacturer in locating good salesmen, agents, or distributors.

Some industrial products are sold by direct mail advertising, but most manufacturers depend upon the salesman for the final step in obtaining orders. The salesman's task is facilitated, if not made possible, when the prestige of the company has first been established in the customer's mind, and he has become familiar with its products through advertising.

An advertising program must be balanced in its use of media, and coordinated and timed with the activities of salesmen. The preparation of advertising copy of various kinds is an art calling for considerable skill, knowledge, and experience. Carefully prepared budgets are an incentive to effectiveness in these matters.

Sales Promotion.—Sales promotion supplements advertising, and is a link in the sales program. It includes publicity, the use of movies, exhibits, displays, demonstrations, and literature which is informative and descriptive. Sales promotion activity should answer questions which the customer may have in mind and thus lead to sales. Literature mailed to prospects or handed to them by salesmen, may be supplemented by demonstrations of the effective use of the machine or product. Another phase of sales promotion work is aiding dealers to increase sales. This may be accomplished by better arrangement or location of stock, use of

[8] Industrial Marketing, by John H. Frederick, p. 198.

window displays, cards, and the like, and advertising material for customer distribution. Candy sales in a Chicago department store were doubled by a better arrangement and display of the stock on the counter.

Sales Work.—The case of the machine tool dealer or distributor provides an example of the sales task and is described as follows by the former president of the National Machine Tool Dealers Association.[9]

Sales work can be divided into four classifications: *Missionary, Responding to Inquiries, Servicing,* and *Contacting.*

Missionary work consists of introducing equipment where it is unknown or where its use was not previously contemplated. This involves the use of descriptive literature, photographs, blue-prints, moving pictures, models, and sometimes demonstrations of the machines themselves. In doing this missionary work it is necessary to know in advance the customer's product and his method of manufacturing and, with this knowledge, lists are prepared of manufacturers who are to be offered specific machines.

Inquiry work consists of following up inquiries originating with the customer, usually resulting from a need for replacement or because of a new or changed product. In this case the salesman's duties consist of immediate investigation of the inquiry, in order to gain the necessary information on which his proposal is to be based, after which he follows up the transaction to sell the merits of his particular equipment.

Service work consists of the demonstration of newly installed equipment when necessary, the investigation of complaints, and the making of corrections either personally or through a factory service man when required.

Contact work consists of maintaining relations with executives of industrial plants, and with the various branches of the industries through the societies representing them.

The dealer's organization must also include the usual office personnel, with a sales manager, auditors, stenographers, clerks, and in some cases, an engineering staff.

Manufacturers selling through dealers furnish sales assistance by providing the necessary literature, photographs, blue-prints, models, moving picture films, and samples of work. In the case of high production machinery the manufacturers also prepare time-study estimates and design and quote on special fixtures and tooling. Some manufacturers have sales engineers to cooperate with their dealers and also provide field men for demonstrating special equipment after it is installed.

Growing Importance of the Consumer.—Sales activities are engaged in to interest the consumers in the manufacturer's products. As has already been pointed out, the early manufacturer was not greatly con-

[9] Marketing Industrial Equipment, by Bernard Lester, p. 64.

cerned with this problem for he came in direct contact with his customers and usually did not start production until orders were received. Modern manufacturing is on an entirely different basis. Goods are now generally made according to the manufacturer's conception of what his customers want and are produced in large quantities prior to their sale. By this means great economies are secured in production costs, but a great element of risk is incurred in estimating the desires and extent of the market. If the consumers of the product do not accept the manufacturer's design, or if the extent of the market is overestimated, large losses will result. In the last analysis it is the customer who must be pleased if business is to be conducted successfully. "By the very nature of things, the bigger an institution grows, the wider becomes the breach between the customer and those guiding the destiny of the institution." [10] Hence the importance of the consumers' tastes and prejudices has increased as manufacturing establishments have grown in size.

Consumer Research.—All manufacturers have recognized this problem and most of them have made some effort to determine consumer desires before they start production. Many of them have developed elaborate means to measure the probable size of the market, but not so many have engaged in a scientific attempt to keep in touch with changing consumer wants as an aid to the development of design and sales efforts. Information received from dealers or salesmen in the field is helpful, but frequently it is not sufficiently detailed or accurate enough to serve as a reliable guide. A recent survey by the United States Department of Commerce indicates that 30% of American manufacturers of consumer goods operating nationally employ customer research in some form or another.

One of the leaders in this new field of determining customer reactions in advance is the General Motors Corporation. Its conception of the need and position of customer research is pictured in Figure 7. "Just as the physical laboratory concerns itself with the qualities and behavior of physical things in relation to problems of design and production, customer research concerns itself with the psychological attitudes and reactions of human beings—not only as regards questions of product design, but as regards the services, policies and procedures surrounding the sale and use of the product . . . We might say that the purpose of customer research is to make contributions to the merchandising function paralleling the contributions that the physicists, the chemists and the metallurgists have made to engineering design and manufacturing processes." [11]

[10] Henry G. Weaver, Director of Consumer Research, General Motors Corp.
[11] From a pamphlet issued by General Motors Corp., Thought Starter No. 90.

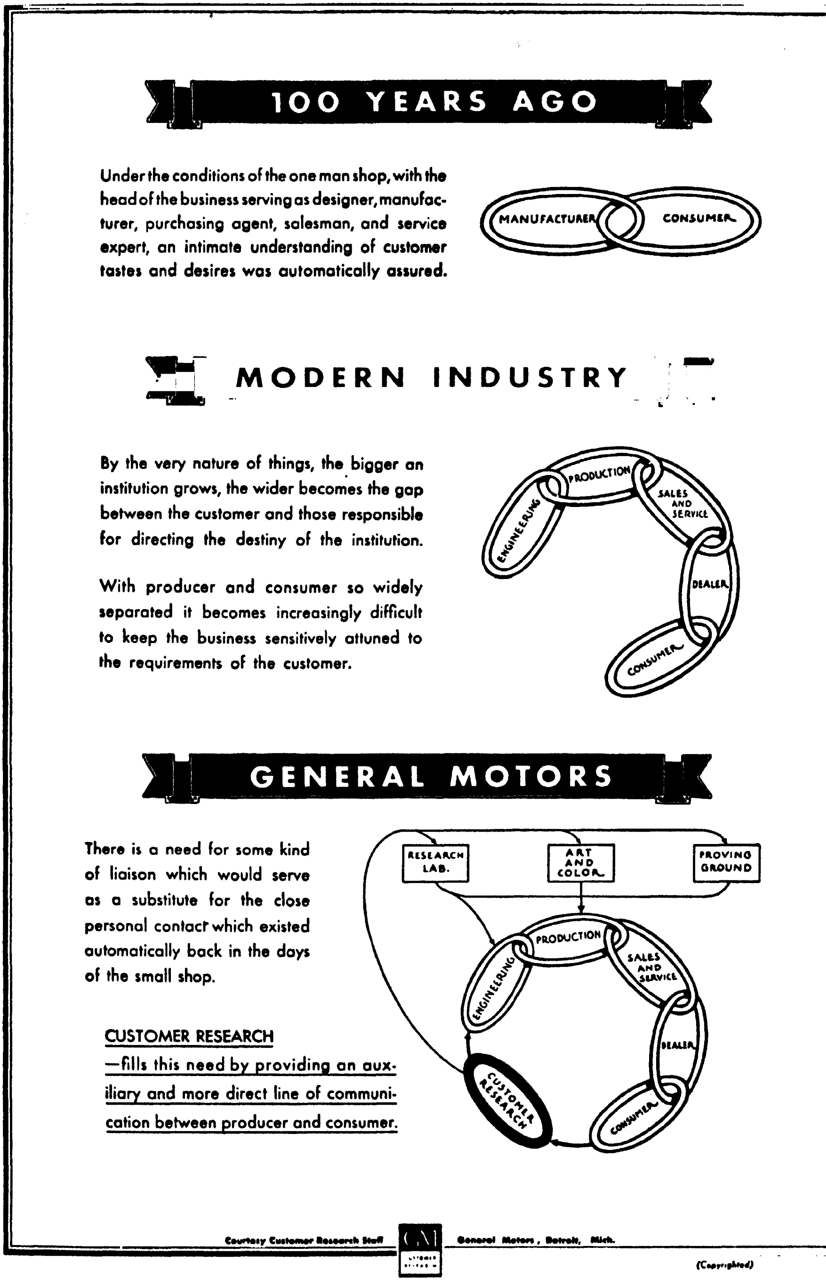

Figure 7. Position of Customer Research in the General Motors Organization

The technique employed by the General Motors Corporation consists in sending out a series of questionnaires to motorists in order to determine the general trend of their desires in motor car design. More detailed information is obtained from a select group of "motor enthusiasts" on technical improvements, and an attempt is made to get facts which will indicate the best way of presenting these improvements to the public. Questionnaires are supplemented by the field surveys and an educational campaign intended to prepare the way for favorable customer acceptance of new designs. For example, style changes are checked before and after being made through a variety of inquiries. Not only General Motors cars but all other American makes are included in the survey. Although sales and advertising aids are obtained as a secondary factor, the main problem is to obtain information on the question of what the buyer wants in the way of a product.

Consumer Research and Advanced Design.—

The maintenance of a consumer research activity does not necessarily mean a blind acquiescence to the expressed tastes and desires of the consumer, which, as applied to a highly technical product, might lead to violation of sound engineering, to constructional difficulties, or to increases in cost outweighing the advantages to be gained. But consumer research does provide the means whereby the consumer may readily pool his practical experience with the technical skill of the manufacturer to the end that the needs, tastes, and desires of the consumers may be brought into proper relationship to scientific research and inventive genius, and most of all into an intelligent union with practicability.

The talent and the facilities represented in the modern manufacturing organization place upon the producer the responsibility for aggressive leadership in his particular field. Mass production technique demands that design and experimental work be done well in advance of the manufacturing program. The maintenance of a consumer research activity in no sense relieves the manufacturer of his obligation to contribute to scientific progress and advances in design which may easily be beyond the concept of the layman. After all, the consumer is more of an expert on use than he is on design. Therefore he can hardly be expected to project himself very far beyond that which he sees and experiences in his daily life.[12]

The Demand for New Products.—In contemporary American society there is a demand for new and improved products. This has not always been the case, but has come about as a result of the impact of modern science and technological invention upon society. So often have

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[12] "Consumer Research and Consumer Education," by Henry G. Weaver, *The Annals of the American Academy of Political and Social Science,* Vol. 182, p. 93.

science and research improved old products and invented new ones that people have come to regard articles which do not incorporate the latest techniques as definitely less desirable than those which do. In some cases this enthusiasm for novelty is carried too far, but on the whole newness is usually backed up by sound research. There are two kinds of changes which have resulted from the effect of science and technology upon products. One is the change in the external design of articles; the other, the improvement of materials and parts. These are not separate and distinct, but are aspects of a single trend which must be more and more taken into account by the sales department. The effect of technical advancement has been to make the public improvement conscious and to create a demand for better and more attractively styled products.

The Influence of Research on Design.—Research creates products heretofore unknown, and, in a very real sense, creates new wants on the part of the buyer. Such things as vitamins, ultra-violet lamps, photographs, electric refrigerators, are all things of this sort. They and innumerable other things like them have changed the social face of western countries. These products of research have changed not only physical habits but customs and attitudes, ways of thought, and ideals; they have profoundly altered our ways of living, and since there is apparently no limit to new products, the coming half-century may be as different from today as today is from 1900. The result of such a constant influx of new things is a society which expects change and even demands it. This gives to living a great deal of variety, and a heightened sense of quality and intensity. It makes necessary the new models in automobiles and other products. It fosters the changes and improvements in every article offered on the market. It emphasizes style, and in this sense, technical research is ultimately responsible for the well-designed pens, stoves, and refrigerators, for the beautiful machinery used in some plants, and for the architecturally perfect plant structures themselves, as well as the technical inventions making these things possible.

The results of invention and research are novel; the effect upon society is a demand for the new, a demand which focuses on styling, and which has resulted in the new industrial architecture, air conditioning, and lighting, in the new forms which manufactured articles have taken, and which are so great an improvement over older models.

Although modern design originates in novelty, it takes its inspiration from utility. In making things better, science and research have emphasized the utility of the articles. An improved pen is a pen that writes better, and an improved light is one that enables its user to see better. It is only a step from this to the design of a pen which in its form

embodies its function of writing, and to modern lighting fixtures which are designed to give optimum lighting conditions. This is a radical departure from older design conventions. Ornaments are not, as they once were, superimposed upon the article. The article now stands on its own feet—the use to which it will be put. Modern cars no longer imitate the carriage; they tend to be designed to afford the least wind resistance and the optimum in traveling comfort. The results are definitely preferable to the older style. The effect of science and research upon sales has thus been direct. It has accentuated the demand for styling and has tended to make this styling functional in character.

Product Design.—If a given product is to satisfy the uses to which the consumer will put it, it must be designed from both an engineering and artistic viewpoint. The demand for new and up-to-date styling has given rise to organizations of commercial artists who together with the plant engineering department work out new styles which can be produced at a predetermined cost. The sales department usually calls in these outside consultants, or in the case of large organizations, its own staff, and the problem of styling a product is first taken up from the point of view of sales. The market situation is analyzed, competitors' products reviewed, an analysis of consumers' needs and desires is made, and from these data the general type and goals of the new design are determined. Having once determined the relation of the new design to sales, the stylist turns to an analysis of the present production methods, for unless the new style is adaptable to the plant methods, its cost will be prohibitive. In the meantime the engineering department has been incorporating the newest technical improvements in tentative drawings. A conference is now necessary between the representatives of the sales, style, and engineering staffs. This conference has the problem of working out what technical improvements must be sacrificed to style, what changes in style are suggested by improvements, and the manner in which these things are to be incorporated in the sales program and the production schedule.

While styling is always involved in product design, it may not be always a fundamental factor. Very often product design is a means of simplifying manufacturing processes, of using interchangeable parts, or of reducing price. Very often a new design originates in the desire to incorporate improved technical processes and equipment for manufacture in the production of the article, and to take advantage of the recent research in the construction of the article itself. However, no design can be complete unless it is developed from the point of view of style as well as technical improvement.

From the point of view of the artist, the production engineer, the research engineer, and sales, the new design must do for the consumer what he wants done, must be adaptable to production, must be economical to produce, and must embody up-to-date technical improvements. The incorporation of all these attributes in the product is a tremendously complicated affair. That it has been done, and that the result is quite generally a beautiful article is a tribute to modern industry.

Services of Industrial Designers.—The problem of designing, as has been noted, is partly a problem of style. It often happens that a plant does not have enough styling problems to warrant maintaining a style staff. In this event, or in case a new perspective is desired, it is often desirable to call in the services of an industrial designer or group of designers. Naturally the capacities of the designers available for this purpose vary greatly, and it should be remembered that since the style of the article is the most apparent thing about it, it is very important to sales. The initial cost of design service should be measured on this basis. The style of an article through its merchandising appeal can do more to break a sales quota than perhaps any other factor. The technique of styling has been highly developed and when done completely is well worth its cost. Styling is not merely a matter of sketching a design on paper, but involves coordinating work with every department in the plant.

The Manufacturer, Research, and Society.—In a society which seeks newness, a manufacturer is forced to employ research. Only along the frontiers of applied science can new products be found, and only through new products can the manufacturer take advantage of the market for what is different. The creation of vitamins in capsule form, the production of new plastics in the chemical laboratory, the introduction of television all give to the manufacturer who first succeeds in offering them to the public an economic advantage. Momentarily such a manufacturer is outside the field of competition, his prestige is increased in the mind of the public, and the advertising value of such an achievement is incalculable.

This emphasis upon the connection of research and future possibilities in manufacture does not omit process research, the development of better ways to manufacture. The possibility of producing many new products has hinged upon the discovery of some way of getting results on the manufacturing line. The modern gasoline engine is the product of "superfinished" cylinders and bearings, a smooth and even surface without which its performance would be relatively low. Modern aircraft are the result of the discovery of a means of processing aluminum ore. A

great many lamp filaments and oil-impregnated bearings can be made only because powder metallurgy has become a reality. Nor does the statement that research is the leader of manufacture into the future omit product research, the improvement of extant articles. Such improvement is often as not a radical change, and unless the development of a product keeps pace with the possibilities opened by pure research it will soon become antiquated and unsalable. There are many relatively routine functions of the research division of a plant, but they center about the application of the latest scientific discoveries to production, either production already begun, or the production of completely different products.

The research division of a plant is, in a sense, insurance, for it makes certain that the plant keeps pace with the times and insures that the future will not catch it without a product to manufacture or an antiquated article. Society demands that industry take advantage of scientific knowledge in producing new and improved articles, and research insures that industry is not failing to meet this demand.

The trend of research in the recent past is definitely in this direction. Preoccupation with minor improvements and processing is being left to the engineering division. The research division is now generally responsible only to the executives of the plant or organization, where action upon radical changes can be obtained.

Services of Research Institutes.—Pure research involves considerable expenditure of capital, both for equipment and personnel. It is now possible for plants not wishing to spend the capital needed, to turn over particular problems to research foundations for solution. These foundations, such as the Mellon Institute, or the Battelle Memorial Institute, are staffed by leaders in industrial science and possess complete equipment and libraries for all types of research. They are not, of course, testing laboratories or engineering staffs. However, any problem involving the development of new techniques, or the analysis of particular problems from a scientific viewpoint, the adaptation of the latest scientific tools to the industrial processes, or the development of new materials is in their field. Problems which go beyond ordinary engineering techniques, and seem to require original scientific analysis can be referred to them.

These institutes usually operate on a retaining fee plus the cost of such additional apparatus as is necessary for the particular problem. They report their findings directly to the executives of the company, and provide a means for obtaining information beyond the scope of ordinary plant routine.

Developing New Ideas.—Since the functions of the research division are not primarily time saving or money saving in character, although incidentally both time and money are often saved in consequence of research work, the managerial aspects of research do not tie in closely with matters of production, wages, and employee relations. The research department is fundamentally more closely related to the sales division, engineering and design division, and to the group of men which determines the policy of the company in regard to radically new products and processes. Such a group usually includes the heads of the engineering, design, and sales divisions together with the director of manufacturing and general manager. This group of men forms the management counsel on what lines research will take. It is a two-way channel. Not only does it decide the general direction of research investigations but also, through its contact with many parts of the organization, it is often a source of suggestions for research. In addition this council decides whether new products originating in research shall be put into production, whether this production shall be organized and developed within the main plant or whether a subsidiary organization shall be set up, as might be the case where the product in question is quite different from the product already being manufactured. Such a council as this provides the best means of allocating problems between engineering design and research. Thus, problems which demand only engineering and designing skills can be steered away from the research division, and the highly technical knowledge there be reserved for problems of this nature.

Within the research department itself there are two managerial techniques for handling problems. One is the assignment of an entire problem to a research worker; the other is the division of a problem into parts, each of which is handled by a specialist. This latter method must necessarily be restricted to problems of a relatively simple order, for unless enough is known about the subject of the problem to make intelligent division possible, this method is obviously impracticable. There is always some work of this type, and usually both methods of attack are used to advantage. It is especially practical to subdivide the problem for the purpose of training new men. However, where the research staff is of a high order the treatment of a whole problem by one man is best for morale and results. The director of research must be a specialist in at least one field, and in addition his knowledge must be wide enough to permit full understanding of all developments. He also must be cognizant of manufacturing, engineering design, and sales problems. He must be acquainted with the possibilities and legal significance of patents. He must be a man of unusual foresight and vision, capable of

seeing final sales possibilities in embryonic ideas, and he must be able to sell these ideas to the executives of the company. Finally, he must be a man of great tact and leadership in order to handle the exceedingly complex personnel problems which are sure to arise among a group of very original and brilliant men.

CHAPTER 3

INDUSTRIAL PROGRESS

The Historical Background.—It has been said that a knowledge of historical backgrounds is essential to the proper interpretation of present problems. Certainly a better understanding of industrial history is valuable to the business executive, for it furnishes him with information regarding changing conditions and trends that will influence his thinking in the formulation of policies. While the statement that history repeats itself is never fulfilled in total, it is true that many modern practices and developments are merely adaptations of customs which were prevalent years before. Growth is accomplished by slow changes rather than by drastic upheavals. This is shown by a study of American manufacturing as it progressed from the early domestic period through the handicraft and home industry stages until a true factory system was developed. Although the United States, because of its late start, did not show these stages clearly, they are, nevertheless, included in the rapid industrial development of this country. Today this nation is the leading manufacturing country in the world, and this situation is the cause of the high standard of living attained by its population.

The Evolutionary Development of Industry.—United States industry in the beginning was essentially European domestic manufacture transferred to a new location. The country was new and primitive, the people poor and with simple needs. Numerous handicrafts that evidenced the varied industrial activity of the colonies developed into factory enterprises. The cabinet maker became a furniture manufacturer; the blacksmith, a proprietor of a machine shop or of an iron works.

An impetus was given to manufacturing by the scarcity of goods during the Revolutionary War period and the War of 1812. The English later endeavored to check this movement by flooding the market with cheap goods of all kinds, but their efforts to maintain control of the industrial field failed, largely because of the rapid expansion and growth of the country. The scarcity of money forced the colonists to produce for their own needs to the fullest extent possible, in order that the small supply of money available might go to bring in needed imports.

The wants of the times were largely for things used in everyday liv-

ing in a pioneer environment. These included textiles from wool and cotton, furniture, household supplies, and leather goods. Iron works established in Virginia and other colonies provided a material used generally for many products. Lumber and furs were shipped to England, and ship building became the first important industry. There is still much similarity in the fundamentals of manufacturing today as compared with the Colonial period. Many products are the same in kind, but with changes and improvements in many characteristics, as in clothing and ships. But buggies and wagons have given way largely to automobiles and trucks. The techniques employed in making goods have changed enormously, and the possibilities inherent in mass production have introduced a new standard in living.

Needs of Industry.—The basic needs of industry remain about the same as they always have been; namely, a place and shelter, tools with which to work, fuel, water, power. Differences today are in the nature of these essentials. The crossroads blacksmith shod horses, sharpened plows, made simple tools, and repaired farm equipment. The building of wagons, later buggies, was an outgrowth of this simple work situation. Accomplishment depended almost entirely upon what a man could do with hand tools, and his own knowledge and ability. Later came the use of machines and equipment obtained elsewhere which enabled him to do things he could not otherwise do, and which also increased his productiveness. This evolutionary process in ways and means of accomplishment has continued until we have today the modern manufacturing plant. "Only now it means that you select a site, spread a concrete floor, raise a frame of structural steel a quarter of a mile long, drape it with a curtain of brick and glass, bring in a railroad, then power and water lines, and after all of that, which is the least of it, come the machine tools, for which you will need an organization of engineers, technicians, skilled mechanics and semiskilled tool operators." [1]

Labor in Industry.—From the foregoing it will be appreciated that the early wagon maker was also an industrialist, and this was typical of much enterprise of early days. The making of articles involved almost all there was to know about the business; and other phases including buying, selling, and finance were simple and learned by observation and first-hand contacts. Those artisans with ambition and an aptitude for business could easily advance themselves. The present-day gulf between mechanic and enterpriser is much greater, and not easily bridged.

[1] "Tanks From a Cornfield," by Garet Garrett, *The Saturday Evening Post*, Vol. 213, No. 48.

However, the way is not closed, and there are other avenues which contribute to gains in living.

Labor in the United States has always been expensive and, until recent years, scarce. We have had experience with forms of involuntary servitude as slavery and indentured labor. Communistic ideas have been tried out. These systems of organization failed to develop the enthusiasm and resourcefulness in individuals needed in a progressing economy, and gave way to the wage system of free enterprise. The cost involved in high wages has always been an incentive to the development and use of machines and techniques which would produce more. Formerly the opportunities afforded in farming and small enterprises attracted industrial workers and set the standard of wage levels. In more recent years the tide has turned and there is now need for industry to absorb large numbers of workers reared on farms. This is because machinery and equipment supplied by industry enable the farm family to carry on without outside help, or with only temporary assistance. The high wages paid in industry have attracted rural workers and at the same time raised wage levels in agriculture. This in turn has favored the use of more labor-saving machinery on the farms.

The unionization of workers in the manufacturing industries was not general until after the turn in the economic depression of 1929. This is indicative to a considerable extent of the favorable position enjoyed by these workers as to wages, opportunities for advancement, and freedom to engage in some form of enterprise on their own account if dissatisfied. Following 1933 the organization of labor was aided by favorable legislation, and labor leaders were successful in greatly increasing the strength and scope of unions. The billions of spending for war production gave a further impetus to the movement. Notwithstanding the fact that many workers were indifferent or hostile to unions, they were carried along with the tide. Agreement between the Ford Motor Company and the C.I.O.'s United Automobile Workers union, which was signed in 1941, ended a four-year campaign against this company, the last of the large nonunion firms in the automobile industry.

The employment of children in the manufacturing industries has been largely discontinued, partly because of legislation in this direction, but more directly because of changes in the work situation, which make the employment of mature workers more advantageous. Women workers increased in industry during the First World War period, but their number decreased later when men were available and as jobs became more scarce during the depression years. The evolutionary development of machines and achievements in the field of work simplification now make it possible for women to perform a large share of the work previ-

ously done by men in manufacturing. Whenever there is a shortage of male labor, as under war conditions, an influx of women into industry occurs.

Skill and Training in Industry.—The crossroads wagon maker of a generation ago was a woodworker, blacksmith, and painter combined. He made a product in its entirety. The growth of industries brought about specialization of effort so that workers devoted themselves to one craft and thereby became more highly skilled and productive. The apprenticeship system prevailed and beginners customarily served four years learning a trade and becoming skilled craftsmen. Knowledge of a trade was passed from master workman to apprentice and absorbed as a part of the learning process. Few workmen had more than the rudiments of school training, yet out of this picture came many of the business men of the past generation.

Manufacturing has become a highly technical and complicated process in most lines, often calling for precision of a high order, or quality characteristics of a degree and character unknown a few years ago. To a remarkable extent production aids have been incorporated into machines and workplaces, jobs subdivided, and tasks simplified, so that the rank and file of workers may be quickly trained and become fully proficient in a few weeks or months. This makes for mobility of workers between industries. Surveys show that in general less than 10% of workers are highly skilled, from 70% to 90% semi-skilled, and the balance unskilled. Periods of training for skilled workers vary from two and one-half to four years, depending upon the amount of high school training received; while semi-skilled workers qualify in from a few weeks to two years. As workers learn one task they may be upgraded by transfer to more difficult work and thus gradually become experienced and capable in performing a variety of tasks.

Transportation.—The evolutionary development of means of transportation has been an important element in the growth and spread of industry. Access to raw materials on the one hand and markets on the other is a prime consideration. Primitive wagon roads localized industry, while waterways gave it a wide range. The railroads opened a vast hinterland to agricultural development and thus created industrial markets. The network of concrete highways and farm-to-market roads built by state programs has recently been improved and expanded by federal contributions. Improvements of our inland waterways have also taken place year by year. Airplane transportation is playing an increasingly important part in the movement of express and freight. Its rapid service also assists executives in reaching branch plants readily

and thus facilitates managerial control. The combined effect of improved transportation facilities, better techniques of manufacture, general accessibility of electric power, the spread of markets, and other factors has been to decentralize industry. An increasing number of manufacturing plants depend in part or entirely upon truck transportation, which has a practical range of several hundred miles, and sometimes more than a thousand miles.

Management Techniques.—A village blacksmith and wagon shop had little need for techniques of management. The owner, possibly assisted by one or a few men, carried on the blacksmithing, woodworking, and painting operations called for. Each workman, assigned his task, depended upon his previous training, skill, and experience for competency in doing his work. The owner and boss was at hand to provide the needed direction and coordination of work activities. In contrast, the larger, modern manufacturing plant is a complex establishment. Management must provide special arrangements to control costs, care for employment and personnel needs, plan layouts and equipment requirements, control quality, schedule production, care for purchasing, inventories, and many other continuing problems. Most of these activities merit the attention of specialists, and often necessitate extensive technical training.

Capital and Credit.—The humble blacksmith and wagon shop contrasts greatly with present-day automobile plants. Emphasis in the past was upon ability of persons to make things, with less dependence upon the character of the workplace and the mechanical facilities provided. The transition to manufacturing plants involving large proportionate expenditures for facilities has been gradual. It now requires an investment of from $6,000 to $20,000 to provide each worker with an opportunity to work. The problems of capital and credit have thus become increasingly important.

The small business man who engages in manufacturing depends for capital upon his own resources and upon friends, acquaintances, and associates who have faith in his enterprise. He may augment the capital accumulated from these sources in several ways, but it is necessary to consider the financial risks involved. Mortgages on land, buildings, and other fixed assets are a common form of obligation used to obtain money loans. Raw materials and other purchases may be upon credit terms. Equipment may likewise be purchased subject to deferred or installment payments. If products are not sold for cash, customer accounts may be pledged for loans, or sold outright. Local banks assist with loans for 60 or 90 days, which may be subject to renewal. The function of

banks is to provide working capital needed for relatively brief periods, not to provide funds needed continually in the business.

Banking facilities are now available in almost all localities. Local or big city bankers will be guided in extending credit to enterprisers by the assets of the company, its ratio of liquid assets to liabilities, its past record and probable future as judged by orders it may have or its budget program for the ensuing year. Of influence also in determining the amount of a line of credit is the judgment of the banker as to the character and ability of the company's executive personnel. As firms become larger, have records of successful management and earnings, and become known to the investing public, funds may be secured by stock, bond, and note issues which will be purchased by investors over a wide area.

Spread of Industry.—Conflicting forces are at work influencing the location of industry. The tremendous demands made upon American industry for the production of all kinds of goods to forward the war program brought about a great expansion of existing plants in metropolitan and other highly industrialized areas. The need to utilize management talent in these plants and areas was almost imperative. Considerable difficulty was encountered in placing government orders or sub-contracts with smaller companies due to lack of facilities, inexperience of management, or reluctance of management to undertake new and different kinds of work under the conditions which prevailed. Difficulties were experienced with quality standards, labor, and governmental controls. On the other hand, social and economic forces have been at work for several years tending to influence the spread of industry to semi-rural and rural locations. When such locations are economically feasible they contribute toward a better balance of our agricultural and industrial economy by enabling workers to depend partially upon gardens, poultry, and fruit of their own raising. With this arrangement the hazards of less industrial employment or unemployment are minimized. Many workers now use automobiles and travel several miles to work over all-weather roads, thus making it possible for them to live at some distance from their work.

Another factor influencing the spread of industry is the unhappy plight in which some communities find themselves due to exhaustion of natural resources or changes in the demands for products. The copper mining area in northern Michigan provides an example of partial exhaustion of a natural resource, and costs of production are now too high for normal market prices. The cut-over forest regions in the Lake states are another instance of depleted resources. In these and other cases resident populations must look to other industries for a livelihood, and

it becomes the task of state and national agencies to assist in establishing manufacturing enterprises most likely to succeed. The ultimate object of economic development is the good of the people, and this serves as a guide in community developments. The coordination of area and regional plans in a national system is receiving attention through the agency of the National Resources Planning Board in Washington, D. C.

Small Plants.—Indications of the spread of industry suggest that small plants may again operate successfully. This is proving to be true. The advancement in manufacturing techniques, improved machinery, widespread availability of power, ease and economy of transportation, and the availability of labor make small plants a possibility. Management talent is also now generally available, which was not the case in past years when college graduates and experienced executives gravitated to the large companies in the cities.

It is estimated that 45% of the wage earners in manufacturing industries are employed by companies with 250 workers or less. These companies also produce about 45% of the products measured in dollar value. A survey by the Illinois Manufacturers' Association in the Chicago district showed that nearly 70% of manufacturing firms employed fewer than 50 persons; that nearly 82% employed fewer than 100 persons; 9%, from 101 to 250 persons; 5%, from 251 to 500 persons; 2.5%, from 501 to 1,000 persons; and less than 2% over 1,000 persons.

Progressive management and the benefits of research are available to small companies through trade associations and other agencies. The American Institute of Laundering maintains an establishment at Joliet, Illinois, which provides its membership with all the latest and best ideas applicable to the laundry business. A school is operated in conjunction with a large laundry which trains men in laundry operation and management. Research is carried on, equipment tested, costs determined, and other problems analyzed. The benefits of all this accrue to the membership made up of individual laundry proprietors throughout the country. The bakery industry has a somewhat similar central organization which makes studies and analyses of problems in the baking industry, and makes available to its members not only printed literature on various subjects, but experts in layout, equipment, and other phases of bakery operation. Annual conventions assist in the educational work. Small firms in allied lines may establish a common manufacturing plant, but maintain separate organizations otherwise, as for sales, engineering, and the like. There is likelihood of more small plants in the decade to come rather than less.

Industrial Problems.—Elements in the manufacturing situation of today which provoke serious thought are: (1) high wages, (2) rising material costs, (3) necessity for low prices, (4) more rigid quality standards, (5) greater competition both at home and abroad, (6) possibility of lower tariffs, (7) increased taxation, (8) political and government interference in business, (9) labor difficulties, and (10) rapidly changing developments in both raw materials and processes.

The cost of raw materials will probably increase, considering that the cream of our natural resources has been utilized, and that mines, fields, and forests have been in part depleted with the pressure of an increasing population. The American standard of living and high wage levels are also firmly established. The latter contribute to purchasing power for the rank and file of the workers, and provide much of the demand for goods and commodities upon which manufacturers depend. But the greatest good to the greatest number will accrue to consumers through lower prices, which serve to distribute the gains effected through better management and technological progress. Higher wages, while desirable and needed in many lines, benefit only a part of the population group. If inequitable, they disarrange the balance of purchasing power among those engaged in agriculture, the service industries, the professions, and elsewhere. Lower prices benefit all consumers—the total population.

Formerly, in periods of economic stress the practice was to cut wages and force raw material prices lower. This was thought to be the only means by which profits could be retained when reduced prices became necessary. Modern management knows there is a better way to secure the desired result. To do this successfully, however, calls for more effective management, greater productive effort, and technological advances. This means the more economical use of materials, new materials, better equipment, greater individual productivity, improved methods, better factory layout, more intelligent and skilled workers, the energetic cooperation of the worker in management, research, investigation, and technological progress; and attention to those neglected but cost-influencing factors—air conditioning, sanitation, lighting, pleasant workplaces, and the health and contentment of the worker.

The problem of successful industrial administration is complicated by the international aspects of trade. Not only are raw materials in part products of foreign areas, but international marketing of finished goods is well established. Thus conditions in one country affect industries in others and interruptions in this flow may disrupt trade at some far distant point in unrelated lines. At a time when the Russians could not afford tea, the growers in India were affected, and likewise the

cotton textile manufacturers in Manchester, England, cotton growers in the United States and elsewhere, and the jobbing industry along the Ohio River. At a time when government influence is tending strongly to increase agricultural and manufacturing costs in this country, autocratic control in other countries is seeking to make them largely or entirely self-sufficient, and to win markets elsewhere. In this way outlets for a considerable part of our agricultural production have been cut off, notably cotton, lard, and wheat, and farm products of other countries are being marketed to an increasing extent in the United States. Japan fostered manufacturing in many lines, including textiles, electrical goods, novelties, and toys. Her exports were not only winning markets formerly enjoyed by English, American, and other manufacturers, but an increasing volume of these goods was finding its way into the home markets of competing countries. Low wages, long hours, and low standards of living of the workers, combined with the use of modern industrial equipment, were important factors contributing to low costs. Notwithstanding the adverse picture presented from the American point of view, it represented progress and held promise of further opportunities for Japanese workers, until war completely disrupted the national economy.

Progress Made in Reduction of Costs.—Management is meeting the test. National programs for the elimination of waste and simplification of products have saved millions, and under the urge of necessity individual manufacturers are cutting costs in every phase of business. During a period covering nine months, the Buick Motor Company reported a saving of $3,500,000 as a result of an intensive study of labor, materials, and scrap. With 5,000 fewer men more cars were produced per day. Some time later Buick spent $15,000,000 in revamping its plant, with low cost, quality production the objective. Again, "In one department, for example, half the workers are producing twice the volume of a year ago. Yet, because of the greater volume of business made possible by the enhanced value of the product, total number of workers on the payroll has been greatly increased. A year ago there were 4,700; today there are over 14,000. Buick's modernization program was a mass attack from all angles. These are some of the channels through which the objectives are being attained:

1. Purchase of new equipment to cut costs, to improve quality.
2. Rebuilding and retooling of existing machines.
3. Rearrangement of existing machines and conveyors.
4. Reduction of number of machines.

5. Smoother flow of materials and parts in process.
6. Reduction of waste.
7. Increase in volume (as related to costs).

"Simplification of product is another main channel of approach to cost reduction in the manufacturing departments." [2] In the automobile industry wages, in a period of eight years, increased 14.6%, cost of steel, 13.4%, and prices declined about 15%.

Another company cut its power bill in half; still another saved $125,000 by consolidating two plants, scrapping the obsolete machinery, and rearranging the rest for more economical processing. In the steel industry in 1929, 458,000 workmen were employed at an average rate of 65.4¢ per hour in producing 175,000 tons daily. In 1936, employment was given to 476,000 men at 73¢ per hour, producing 146,000 tons daily. By 1939, the average wage had increased to 84.2¢ per hour, and 483,000 workmen were employed—5% more than in 1929. In comparison, the earnings of English steel workers were 34½¢ per hour; German, 29¢; Belgian, 16¢; and Japanese, 8¢. A small packing company reorganized its production facilities and was enabled to pay more to the farmers, and to increase wages. Other ways and means utilized to effect economies include air conditioning to control quality and maintain production levels, added shifts or continuous operation of plants to spread overhead costs, and in the case of textiles, to improve quality, and motion and time analyses of operations. Increased administrative and technical efficiency has made these accomplishments possible.

During and following the First World War workers manifested an interest in management and a desire to be represented and have a voice in matters affecting their interests. This was achieved through trade unions, works councils, company unions, shop committees, and other forms of worker representation. Many of these agencies successfully served the interests of all concerned. In more recent years nationally organized labor unions have tended to dominate the field. National legislation and a friendly administration at Washington have furthered the establishment and growth of such unions in important industries. There has been difference of opinion as to the wisdom of establishing such a powerful, centralized control of labor, but this is a problem for which time alone can give the answer.

In the field of marketing, the last decade has witnessed remarkable progress. The principles of psychology have been applied in advertising, standards of truth have become more firmly implanted, and

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[2] "Buick's $15,000,000 Bid," by Harlow H. Curtice, President, Buick Motor Company, *Factory Management and Maintenance*, Vol. 93, No. 12, p. 498.

scientific market analyses have been the basis for finding the most profitable territories and methods of marketing. Much progress is being made toward effecting economies in distribution.

Government Regulation and Participation in Business.—An increased social consciousness has made itself manifest in both political and industrial circles. The beginning of this movement can probably be traced back to 1890 with the passage of the Sherman Anti-Trust Act. At that time the public became alarmed over the power acquired by certain large industrial firms, with the result that legislation was enacted with the purpose of curtailing monopolistic consolidations. The fight was waged bitterly without a great deal of success, for corporations continued to grow in size and influence. Nevertheless, a step had been taken, and the idea that industry should be conducted for the benefit of the entire social structure steadily gained ground.

Within more recent years a great impetus was given to this thought, with the national government leading the way. Much legislation was passed dealing with the organization, financing, and conduct of business enterprises. Labor's right to organize and deal collectively with management was stated, and minimum wages and maximum hours of work per week set. Child labor was prohibited. In certain cases, notably in the production of electrical current and materials needed for war, the government established publicly owned plants. Restrictions in the use of essential raw materials and the manufacture of certain "luxury" articles were made effective as a means of stimulating the production of war materials. Priorities were established and selling prices controlled.

All of these acts indicate a greater participation of government in business affairs. For the industrial manager they mean that his responsibility is greatly increased and his importance in society enhanced. A definite trend has been established away from the individual profit motive toward greater service to humanity. Many of our industrial leaders have recognized and followed this ideal in the past, but their example was not sufficient in itself to cause universal acceptance. Individual initiative is a priceless possession that should not be destroyed, but when a conflict arises between the individual's interest and the welfare of the group, the larger force should prevail. It is the task of industrial management to keep this goal in view, while at the same time the benefits derived from an individualistic system are retained.

Conclusion.—Not all industry is in the vanguard of progress, but the way has been shown, and lagging organizations pay the penalty of their lack of foresight. The life of the average industrial concern, the concern that neglects to improve its methods, lasts but from five to seven

years. It is true that our experience with industry as now organized and with the problems of the present day is of relatively short duration. Nevertheless, the historical perspective of the past provides a basis for attacking the problems of the future, and the mistakes of the past need not be duplicated. New standards are constantly being formulated which serve as a check to retrogression and a spur to further achievement. The science of management is new but growing, and skill in the art of applying the knowledge gained is increasing. The possibilities of the future, perhaps infinite, can only be conjectured.

The road beyond necessarily leads out of the present, and as a preparation for industrial leadership, a thorough knowledge of past practices and an intelligent attitude toward existing thought are of prime importance. Individual experience, taken by itself, is both a costly and an insufficient teacher. General principles must rest upon a wide range of experience. Organized knowledge comes only with a systematic summary of what experience has taught thousands. Study of general principles and accepted practices, available through formal education and books, develops a point of view which is both broad and social in basis, and definitely individual in its application. For constructive thinking in the field of industry and breadth of judgment in handling affairs, such knowledge and understanding are essential. The aim of the succeeding chapters is to supply this understanding.

CHAPTER 4

SCIENTIFIC MANAGEMENT

The Mechanical Age.—The industrial revolution which began in England some time during the last half of the 18th century is generally looked upon as ushering in the first great change that occurred in the art of manufacturing. Most of the inventions of the period centered in the textile industry. The most far-reaching development, however, was the substitution of mechanical power for that of human beings. This was accomplished by James Watt's improvement of the steam engine, which received its first industrial application in 1785. The new mechanical age, inaugurated by steam, freed the mass of the population from being mere muscular sources of power. From that time on men were to be employed more and more as directing agents for mechanical instruments. A premium was placed on knowledge and intelligence, and education of the workers became desirable. Large aggregations of capital in the form of factories became common, and new modes of transportation by rail and water became possible.

Steam, however, was only the first phase of the great mechanical revolution. Not as much attention has been given to the later developments, but they are equally important. These were the application of electrical energy to power, light, and traction and the invention of the internal combustion engine which made the automobile and the airplane possible. The use of electricity as a power source made practical the transmission of energy over long distances and in enormous quantities. The internal combustion engine, gasoline and Diesel, has been employed mostly in extending transportation, although it is used to some extent as a direct source of power. Both of these developments belong to the period following 1875, and although they cannot be credited to any one country, they have had their greatest application in the United States.

America's Contribution.—Starting about 1875 several important changes took place in the American industrial scheme. It was at this time that the United States began to emerge as the leading manufacturing nation. By the end of the next 50 years the American system of industrial management and mass production was firmly established and was being spread to and copied by other countries. The changes referred to may be grouped under these heads: (1) financial, (2) technical, and (3) managerial.

Financial Structure.—The most prominent feature of the industrial picture during this time was the growth of the corporate form of organization and the increase in size of our business enterprises. In some fields natural resources and monopoly privileges of almost limitless value were acquired by bold and far-seeing individuals, while in other fields control was obtained by means of patent rights and exclusive knowledge of new processes. Large fortunes were accumulated by many persons, but on the whole these were relatively few. The names of Morgan, Carnegie, Rockefeller, and Ford come readily to mind. Ownership was pyramided by means of trusts and later the holding companies. Big businesses, with large financial interests and resources, were the order of the day. It was an individualistic period with only a vaguely realized social consciousness. The true administrative method of exercising control and achieving results by subordination of authority and the direction of others developed slowly.

Technical Improvements.—Besides the great use made of electrical power and the employment of the internal combustion engine in the movement of people and products, American ingenuity also turned to other fields. New machine tools of all types were invented or old ones greatly improved. Old hand-operated machines were made automatic. Many new industries were developed, especially those relating to electricity, automobiles, motion pictures and airplanes. The steel industry made particularly rapid strides at the beginning of the period, followed by petroleum, and after the First World War by the chemical industry. Handling equipment and transporting devices within the plants were greatly improved and put to more general use. The standardization of products and parts led to the technique of mass production which became the control theme of numerous industries. Eli Whitney had indicated the way years before, but it was left to the automobile manufacturers, and to the Ford Motor Company in particular, to demonstrate the possibilities of this method of production.

Management Methods.—The old type of manager was autocratic, forceful, and usually self-trained. Leaders carried the full load of responsibilities, and enterprises were but the lengthened shadows of individual abilities and personalities. Practical men, experienced in actual operations, they groped oftentimes unsuccessfully for the underlying principles of successful business administration, depending for success upon the driving force of dynamic personalities coupled with monopoly advantage or unusual profit opportunities. With the growth of industry, the spread of markets made possible by better transportation facilities, and the increasing complexity of production, the need for better trained

men became apparent. The writings and lectures of Charles Darwin and Thomas Huxley in biology and of Herbert Spencer in philosophy profoundly affected the thinking of the people in the United States about this time (1875–1900). Men began to realize that old ideas and practices were not always the best. They began to seek for basic principles instead of being content with surface appearances. The scientific approach of investigation, analysis, and experimentation was applied to human activities as well as to biological and physical facts. Although a few men in other countries saw the possibilities of applying the scientific approach to industry, it was the work of certain leaders in the United States, just then emerging into industrial prominence, that raised management to the position of a profession by use of the scientific method.

Scientific Method Now Held Indispensable.—In early plants the technique of manufacturing, the actual application of skill and effort in the conversion of materials, was the important thing. Supervision of operations was incidental and accomplished by the giving of verbal instructions. In present-day plants, except in some small shops, the effective direction of men, control of materials in work, and the successful coordination and operation of the many departments call for specialists in operation and management, quite irrespective of the need for experts in the technique of manufacture. This necessity is a natural consequence of increase in size of factories, complexity of processes, specialization of labor, and diversity and volume of products manufactured.

Early Work in Scientific Management—Henry R. Towne.—The added importance of the management function was first given definite expression in the address of Henry R. Towne, delivered in 1886. He emphasized the importance of "questions of organization, responsibility, reports, systems of contract and piecework, and all that related to the executive management of works, mills, and factories, . . . time and wage systems, determination of costs, whether by piece or day work, the distribution of the various expense accounts, the ascertainment of profits, methods of bookkeeping, and all that enters into the system of accounts which relates to the manufacturing departments of a business, and to the determination and record of its results."[1] Towne stressed also the function of forms and blanks as a means to expedite production and facilitate control. In short, he gave particular attention to the

[1] "The Engineer as an Economist," by Henry R. Towne, president of Yale and Towne Manufacturing Company, *Transactions of the American Society of Mechanical Engineers*, Vol. 7, p. 429.

nontechnical or business side of production operations, the lack of which was creating severe economic growing pains in industry during its rapid transition from youth to maturity. Although during the years which followed, interest in these ideas was to become general, one man in particular, through his superlative powers of analysis, reasoning, persistence, and initiative in execution was to create, almost unaided, an enduring science of management. Frederick W. Taylor laid the foundation and reared the structure of present-day management, leaving for those who followed the task of development. The application of principles to specific situations is by no means an easy matter. The work of the industrial manager is comparable with that of the architect, in that every problem calls for originality of expression. Perfection of achievement is as difficult for the manager as for the architect.

Frederick W. Taylor.—Frederick W. Taylor was born in Germantown, a suburb of Philadelphia, of cultured parents having some means. As a youth he spent three years in travel and study in Europe. Returning to the United States, he prepared for Harvard with the idea of ultimately following his father's profession of law. Hard study, however, injured his eyes, and this seeming misfortune changed the whole current of his life. Instead of entering Harvard, he went to work in a machine shop and learned the trades of pattern-maker and machinist. The work evidently proved absorbing, for although his eyesight was restored, he presently went to the larger plant of the Midvale Steel Works of Philadelphia (1878). Because of the dull times he began to work as a laborer, but progressed rapidly as a time clerk, lathe hand, gang boss, shop foreman, and ultimately to the position of chief engineer, all within six years. At the same time, by study at night, he qualified for and received the degree of Mechanical Engineer at Stevens Institute. His versatility of interest is indicated by his participation in amateur theatricals and athletics—he was a champion tennis player—his success as a mechanical engineer, in experimental research, and as an executive. He early achieved a passion for perfection, for finding the one best way, for persistence and thoroughness in all his work and play.

Taylor's "Duties of Management."—At Midvale, between 1880 and 1890, Taylor developed the principles of the science of management, which were to influence industry throughout the world. As a workman, he realized that his fellows were "soldiering" [2] on the job. As a foreman, he considered it his duty to break up the practice, carried on at first with the motive merely of protecting favorable piece rates. Manage-

[2] Loafing.

ment's difficulty was that, as no way of measuring a day's work was known, no effective incentive could be offered for accomplishment. Taylor perceived that if piece rates were based, not on actual performances in the shop, but on the facts as revealed by a careful investigation, then management could fairly ask for and reward definite performance. The motive for "soldiering" would then be destroyed. Under the existing regime management lacked control, and it became the object of Taylor's endeavors to gather the information and formulate principles of operation which would enable management really to manage. He had no narrow conception of his task. While increased production was his primary object, he realized full well and was concerned with the possibilities for bettering the worker's status, increasing his wages, decreasing prices, and providing employers and employees with a common aim and common interests. His ideas finally took shape in four fundamental principles which he termed duties of management, as follows:[3]

First: The development of a science for each element of a man's work, to replace the old rule-of-thumb method.

Second: The selection of the best worker for each particular task, and then the effort to train, teach, and develop the worker, in place of the former practice of allowing the worker to select his own task and train himself as best he could.

Third: The bringing of the science to the worker, and cooperating with him, to the end that all work might be done in accordance with the principles of the science which has been developed.

Fourth: The assumption by management of the responsibility for the foregoing, and for planning the work.

In the first principle Taylor had in mind that the worker was limited to a narrow range of experience, teaching, and observation, and that consequently the usual way of doing a task was seldom the best way. He believed that management, with its facilities, could gather traditional craft knowledge over a wide range, and by further analysis, research, and experiment evolve the one best way of doing each job. The modern personnel department performs the duty outlined in his second principle. Taylor utilized the "instruction card" to take the science to the worker, and developed the plan of functional foremen, each skilled in a phase of the task, to aid him, when necessary, in doing the work successfully in the manner prescribed. Taylor believed that these duties and the planning of the work in the shop should be the functions

[3] Frederick W. Taylor, by Frank Barker Copley, Vol. 1, pp. 14–17.

of management, since management alone is possessed of the necessary facilities, finances, and abilities.

Experiments in Effective Management.—One of his first steps was to seek to determine what his men could accomplish with the equipment and materials provided, an achievement considered impossible, but which if successful would enable him to prescribe what they should do. This led him to the development of time study. The establishment of definite "task times" necessitated standardization of all factors influencing the task. This involved study and action with respect to tools, equipment, materials, operating conditions, and the like. The extent of work involved in this may be appreciated from a later statement of Taylor's to the effect that from two or three months to two years were required to prepare a shop for operation under scientific management.

As he made progress in one direction other steps were suggested, and his activities eventually included the full range of managerial activities. His functional foremanship plan was simply the outgrowth of his effort to make his organization more effective. His differential piece-work plan, devised later, was an effort to reward unusual accomplishment with an unusual wage, and to select the best men for a particular task. His ideas as expressed in principles, policies, and procedures, although derived from experience in the metal trades industry, proved to be of fundamental value in all types of business. These various phases of his efforts will be considered more in detail in succeeding chapters.

While at Midvale, it was this spirit of analysis and research that caused him to undertake, with Maunsel White, experiments in metal cutting which led to the development of a high speed steel of inestimable value. The experiments were continued for a quarter of a century, consuming 800,000 pounds of metal and entailing a cost of $125,000. It was demonstrated that machines could be run at greatly increased speeds when tools made of this steel were used.

Taylor's Later Activities.—Taylor left Midvale to accept an attractive offer with a company which he operated with success for three years, after which he spent several years as a consultant in management. In 1898 he joined the staff of the Bethlehem Steel Company where he spent three years in installing and developing his methods and continuing his metal cutting experiments. His work here met with opposition, however, and in spite of much favorable accomplishment he was not successful in winning the active cooperation of the management. After his departure with his associates, many of his ideas and methods were discarded.

Taylor's career was a stormy one. He was inflexible in his ideas and purposes, often lacking in diplomacy and tact. His practices and methods were revolutionary, and, as he said, required a "complete mental revolution" on the part of those in charge to the extent of "recognizing as essential the substitution of exact scientific investigation and knowledge expensively obtained for the old individual judgment or opinion in all matters relating to the work of the establishment." As he was so far advanced in his philosophy and ideas, it was inevitable that the mental inertia of managers should sometimes prove a stumbling block, and account for the decay of his systems in some plants when his stimulating personality was removed. The penalty of leadership is too often derision, and Taylor suffered this penalty.

Taylor retired from active practice when only 47 years of age, in order to devote his time to writing, lecturing, and promoting the art and science of management as he conceived it. His first book, *Shop Management,* appeared in 1903, and was followed in 1911 by *The Principles of Scientific Management.* Many honors were accorded him in these years. In 1906 he was elected president of the American Society of Mechanical Engineers, and it was before this society that he presented his notable paper on "The Art of Cutting Metals." His death, March 21, 1915, was premature, as he was only 59 years of age.

Other Leaders in the Work.—Upon Taylor's retirement in 1901 from the commercial field, a gradually expanding group of followers and associates continued to carry the doctrines of good management to the industrial public. Prominent names of this period are those of Henry L. Gantt, Harrington Emerson, Carl Barth, Sanford E. Thompson, Lillian M. Gilbreth, and Frank B. Gilbreth. Some of these management specialists were markedly individual, developing methods and systems which differed in detail from Taylor's, although fundamentally similar and with the same aims and objectives. Capable and conscientious, their work was good, although not widely advertised at the time. By avoiding Taylor's mistakes and working independently, they averted much hostile criticism which had centered about "Taylorism," as the new practices and procedures inaugurated by Taylor were called.

Public Interest Aroused.—Almost overnight the public was aroused to an intense interest in scientific management. In 1910 the railroads sought marked rate increases and national attention was focused on the hearings held before the Interstate Commerce Commission. At one point in the proceedings the counsel for the shippers contended that the adoption of scientific management by the railroads would save them far more money than they would gain by the proposed rate increases.

Much testimony by owners and managers of "Taylorized" plants was introduced to prove the assertion. A number of management experts were called upon, and one of these, Harrington Emerson, testified on the basis of railroad shop experience, that the railroads could save $1,000,000 a day. This phase of the testimony caught the imagination of the public; and time study, the efficacy of systems, the merit of incentive wage schemes, and stories of economies effected became popular topics of discussion, even with the man in the street. Very quickly magazines responded to this interest with explanations and descriptions of scientific management in operation. The term "efficiency," popularized by Emerson, became a slogan in business, and scientific management was definitely established.

Era of the "Efficiency Experts."—The demand for efficiency experts caused an influx of impractical, incompetent, and narrow-gauge men into the field as consultants, who nearly wrecked the movement. Many of these individuals had been foremen, superintendents, or had perhaps assisted in installing systems or operating them. Their experience was often as shallow as their vision was limited. Unfortunately, too, employers were usually concerned solely with immediate profits. They disregarded or were ignorant of Taylor's ideals with respect to labor and the general principles back of his work. As a consequence, workers were treated simply as adjuncts to machines, and operating and even executive procedure fitted into cut-and-dried systems. The attempt was made to cover, in weeks, work which should have occupied months. These attempts to mechanize plants invariably proved disastrous, for the human equation, patience, and thoroughness are always of paramount importance. Labor and union organizations were provoked to bitter hostility which persists in some quarters even to the present. The futility of attempting to apply management by means of rubber stamp methods, or of seeking to benefit one group at the neglect or expense of another, was clearly demonstrated at this time.

A succeeding wave of "industrial engineers," experts in one or several phases of management, followed the efficiency men, and almost as quickly passed into oblivion. It became increasingly evident that management could not be successfully applied from the outside by prescription, or by the inauguration of fixed systems based upon a superficial understanding of plant practice and knowledge of the available personnel. The introduction of a stranger who even indirectly tells everyone how to do his job will never be a popular mode of increasing efficiency. Management must come from within.

The Present Situation.—Today management talent is included as an inherent part of each factory organization. In large concerns this is carried to the extent of having specialists in charge of each function of management who are experts in their respective fields. Individuals may also be employed, without administrative duties, whose energies are given to staff activities for the benefit of line officers. In organizations of medium size, staff assistance of this character is usually not so specialized in its work as in the larger concerns, and dependence may be placed on outside consultants for supplementary service, and for occasional aid in connection with the more important and difficult problems.

Small firms may combine the administrative and staff functions in the same individual. In such cases the danger is that the routine work of direction will monopolize executive time, and the inspiration which comes from study and research will be cut off. For executives in this latter group the staff service provided by the consultant in management is often invaluable. One of the principal advantages of this suggested combination of the inside specialist with the outside consultant is the assurance that any procedure inaugurated will be administered competently later on. Under the old plan even good systems installed by outsiders failed to function after the departure of those responsible for them because their operation passed into unfriendly hands. It must be borne in mind always that any system or scheme, though intended for a special purpose, must merge with and form an integral part of the general production plan. The inside man's perspective aids in fitting new ideas effectively to local needs.

Consulting Service.—The range of consulting service is as broad as business itself; but individual firms usually limit their services to fields of specialization. Certain firms will analyze the problem of location, prepare layout plans, select equipment, design and supervise the construction of buildings, acting in a professional capacity for the owner on a fee basis. These same firms serve existing plants with respect to air conditioning, lighting, industrial power, and plant rehabilitation work. The more frequently used forms of consulting service have to do with operation and deal with such phases of management as motion and time analysis, wage payment plans, industrial relations problems, foremanship training, layouts, production control, budgeting, and cost determination. Other forms of consulting service have to do with appraisals, income tax returns, market surveys, and sources of raw materials. Economic analyses summarizing benefits expected should accompany technical reports and estimates of proposed engineering work.

Value of the Consultant in Management.—The consultant in management is a valuable agent for several reasons. He is usually of exceptional ability in his field; the type of man the ordinary concern does not require for full time service and could not afford to employ regularly. Coming from the outside he brings with him a new viewpoint, is free from prejudice, and is not influenced by the opinions of others in the organization. He brings to bear on each problem a wealth of ideas and information gained from his constant contact with other organizations, which is available in no other way. Inexperience of the consultant in a particular industry may be an asset rather than a liability. Arrangements, methods, and procedures are surveyed with a critical general intelligence unhampered by traditional ideas. Consulting service aids in keeping organizations from getting into ruts, acts as a stimulant to the management, and checks the soundness of internal developments. If an inside man is working with the consultant, he is enabled to check the work of the consultant and to modify recommendations in the light of a more intimate understanding of plant needs and personalities. Through such cooperative methods, also, programs of education may precede gradual changes, averting the dictatorial procedure and "shakeups" so detrimental to plant morale. Evolution rather than revolution is now the policy in management procedure, as it affects the human element.

Management's Responsibility.—A constantly increasing supply of goods and commodities is an important factor in social progress. As a consequence, industry represents a center of interest in our national economy for all population groups. Suppliers of raw materials are interested in the prices paid for their offerings, labor in wages, investors in dividends, executives in salaries, distributors in earnings, consumers in prices of products, and the public generally in the contribution which industry makes to social and economic progress. The task of management is to harmonize the interests of all in a common program.

Conflicting demands made by these various groups impose upon management the need to maintain a reasonable balance and equity between them. Maladjustments, if extensive, may prove serious. The agricultural implement industry provides an example. A disparity between the prices which agriculture receives for its products, and the prices of the things it buys tends to disrupt our national economy. This may come about because of adverse market conditions or when the costs incident to production of farm implements bring about inequitable prices. In either event sales decline. As a consequence groups engaged in the production and distribution of farm implements, and in turn those supplying the physical facilities they use, are not kept busy. An increasing use

of modern farm machinery is in the public interest, for it contributes to lower costs in the production of foodstuffs and of raw materials for industry. Thus it is seen that what is harmful to the interests of any one group will prove disadvantageous to all others.

Management's responsibility may be summarized as follows:

1. To see that the public is benefited by low prices.
2. To see that the workers are paid equitable and adequate wages.
3. To see that the owners are rewarded with dividends, or payment for money invested.
4. To see that the industry is a constructive social force in the community.

CHAPTER 5

OWNERSHIP IN RELATION TO MANAGEMENT

Legal Forms of Organization.—The legal form of organization of a manufacturing establishment is important to its organizers, investors, and to those who deal with it. The legal form of organization largely determines the permanency of the business, influences its financing, governs the extent of an owner's or investor's control, determines what share of profits he may receive, and the risk he assumes. Forms of organization include (1) the individual proprietorship, (2) the partnership, (3) the joint stock company, (4) the business trust, and (5) the corporation. The first two forms are characteristic of small enterprises; the corporation, of companies with a capitalization of $10,000 and upward.

The Individual Proprietorship.—An individual may establish himself in business without any formalities. He is unhampered in conducting it, and at his own discretion, may vary its nature or discontinue it entirely. The profits are his own. He necessarily assumes complete financial responsibility for all transactions. With the exception of certain exemptions granted by law, all he owns and possesses may be claimed by creditors in the event of failure. This is true even though but a small share of his fortune is actually invested in the business concerned. Because of this, the credit which is extended to an individual proprietorship may be very liberal, and is based not so much upon the business, as upon the worth of the proprietor. However, as the business grows and relatively large amounts of capital are needed, this becomes a handicap rather than an advantage. The progress and success of the enterprise are almost wholly dependent upon the ability and skill of its owner, and it comes to an end at his death.

The limited capability of one man is a hindrance to growth. Although specialists may be employed for different phases of effort, the individual proprietorship is essentially a one-man enterprise and usually not as effective as an organization of several men mutually interested in the success of the undertaking. Capable employees find it relatively easy to engage in business on their own account, or if gifted in some specialty, find positions of greater responsibility with larger companies.

The Partnership.—From the standpoint of liability to creditors, the partnership is very similar to the individual proprietorship. From the standpoint of administration, however, it differs from the individual proprietorship in that there is a divergence of administrative responsibility. Each partner is an agent for the partnership as a whole and for all members of the partnership. Each partner is liable individually, and as a partner, for all debts created by the partnership. However, an equal division of opinion among partners, which is known to the outside party concerned, precludes action on any proposed business transaction until a majority opinion is reached. Partnership arises out of a contract, expressed or implied, between individuals, and in the absence of an explicit agreement to the contrary, the members share management, profits, and losses equally, regardless of the variations in the amount of capital invested by each or the time when the capital was put in. This arrangement increases credit possibilities, may add financial strength, and broadens the scope of effective administration. The considerable cost and legal detail incident to organizing and operating as a corporation are avoided.

Department stores are frequently conducted as partnership enterprises, even though of considerable size. Management authority and responsibility may be divided among the partners as agreed upon, and in accordance with their respective talents. Decisions may be made and action take place without delay. These characteristics are essential in a business which must meet the competition of specializing firms, take quick advantage of buying opportunities, and dispose of merchandise advantageously in a market influenced by style, seasons, weather, purchasing power, and other factors.

Classes of Partners.—As regards administration, partners are grouped according to their participation in the management. They may be (1) general partners, or (2) some form of special partners, as silent, secret, dormant, or nominal. As regards liability to creditors the partners are classified only as (1) general and (2) limited.

The term "general partner" has no legal significance, as applied to the members of an ordinary partnership. It is used for the purpose of distinguishing the members of a limited partnership whose responsibilities are not limited. In a limited partnership, the liability of one or more of the partners, but not all, is limited to the amount contributed by him to the firm's capital at the time of forming the partnership. Such limited partnerships, arising by special contract, exist only when the partners and their partnership comply with all of the requirements of the statute which gives authority for the creation of such an organization. Under

what is known as the "Uniform Limited Partnership Act," adopted by many of the states in the United States, a limited partner has no control or management of the business and cannot be an administrative officer.

Whether a partner is secret, silent, dormant, or nominal is a question of degree as to his participation in the management of the firm, and the extent to which this is revealed to the public. A secret partner is one who is connected with the firm but not announced to the public. A silent partner is one who may, by mutual agreement, have no voice in the management, although he is equally bound with the other partners as regards outside parties. A dormant partner, in his relationship to the partnership, has the characteristics both of a silent and a secret partner. Such a partner, not having been made known to the public, may retire without giving notice. The term "nominal partner" has been applied to a person who, though not actually a party to a partnership agreement, has permitted partnership liability to be attached to him by conducting himself as a partner. This is for the protection of those who may extend credit under the induced misapprehension that a certain individual has a financial interest in the enterprise.

Partnership Rights.—In a partnership agreement each partner has the right to an equal voice in the management. In ordinary matters relating to the conduct of the business, the decision of a majority of the partners is controlling. The majority can do nothing, however, that is inconsistent with the carrying out of the partnership agreement, that is to say, they cannot enter into a new line of business, admit new partners, or dispose of partnership assets.

Each partner owns an undivided interest in all of the partnership assets, but he cannot sell, assign, or dispose of any of the partnership property. The only way in which partnership property may be disposed of is by consent of all of the partners. All that a partner owns in a partnership asset is the right to have an accounting, in order to determine his proportionate share of the money value of the assets of the firm. If a partner wishes to transfer partnership property, in any way which is outside the scope of the partnership business, he can pass title only subject to the equitable right of the remaining partners.

A partnership may terminate at a specified time provided for by the partnership agreement, or, if all the partners are willing, it may terminate at any time. Since, however, a partnership is formed by an agreement, it is automatically terminated by death, insolvency, insanity, or other legal incapacity of one of the partners.

Because of these facts and also because of the difficulty of collecting judgments against the many partners, long-time credits are difficult to

obtain. Therefore, a partnership does not offer good inducements for large investments of capital. It is, however, a desirable organization for business where the capital investment is small and the number of partners is not large. Certain benefits may also be secured in matters of taxation and government reports required.

The Joint Stock Company.—This form of organization resembles the corporate form in some respects, and avoids some of the disadvantages of the partnership. Ownership is represented by shares of stock in the possession of partners; and the shares held by each one determine his interest, the extent of his control of the management, and, as between partners, the extent of his liability for losses. Each shareholder or partner is responsible for the debts of the business, however, regardless of any arrangements among its members to the contrary. Unlike a partnership, ownership is readily transferable by sale of shares, thus assuring the continued life of the company. Management is not carried on by the partners, but is exercised by an elected board of directors. Property of the company is held in the name of trustees, usually chosen from the board of directors.

As compared with a partnership, the joint stock company form of organization has two distinct advantages: namely, continued existence by transfer of shares of ownership, and consequent greater ease of securing capital. The chief objection is that individual members are liable for the debts of the firm. Articles of organization must be filed with state authorities, and stock companies are subject to state control. The expenses incident to organization are small as compared with corporations, organization procedure relatively simple, and later requirements as to taxes and reports minimized. The company may operate under a firm name descriptive of its activities, and may sue or be sued under that name. This form of organization is used in England quite generally, but less frequently in this country. Characteristics of joint stock companies here are a closely held, continuing ownership and small hazard, the latter due to the nature of the business or the decentralization of risk.

The Business Trust.—The business trust, or Massachusetts trust, as it is sometimes called, consists of a property administered by trustees for the benefit of its owners in accordance with the trust agreement. Title to the property is vested in the trustees, together with exclusive rights of management and control. The owners hold trust certificates as an evidence of ownership, and are known as beneficiaries of the trust. Personal liability of beneficiaries is limited to the value of the trust shares held.

The formation of a trust is simple, economical, and it is not subject to organization fees, annual franchise taxes, or laws limiting procedure

and requiring burdensome reports, as are corporations. In this way it resembles a partnership. The trustees elected must assume full and unlimited liability for all transactions entered into. The only exception to this rule is when a clause is inserted into contracts which provides that liability is limited to the extent of the trust property. It is important to note that the trustees act as principals and not as agents of the beneficiaries. The latter do not possess power to remove trustees or to participate in management. When this occurs, the courts construe the organization to be a partnership, and place unlimited liability upon the holders of the trust certificates. Trustees are liable to the beneficiaries for losses only when guilty of negligence or fraud in the handling of trust affairs.

The Corporation.—A corporation is chartered by the state and is subject to state control, although for the most part the control is only formal. A certificate of incorporation will include the following information: (1) the name of the corporation, (2) the purpose for which it is formed and the nature of the business to be transacted, (3) the amount and kinds of capital stock which can be issued, (4) the length of corporate existence, (5) the number of directors, and other data.

The fact that the corporation is formed under state laws gives a prestige with investors. They expect this control to safeguard their interests, as in various ways it does. The corporation must comply with state laws governing corporations and with the special provisions of its charter, and must file annual reports with the Secretary of State. Ownership is divided among the stockholders, who elect a board of directors to govern the business. This group chooses a president, establishes the policy of the business, and to a greater or less extent influences its management.

Stock may be sold from one individual to another. Stockholders are not ordinarily liable for the debts of the corporation. This limitation of liability to the amount of stock owned is a large factor in attracting capital. However, in recent years legislators in some states have imposed added obligations upon stockholders in the form of double liability, or for unpaid wages to employees. A recent law in Illinois makes stockholders liable for unpaid wages of employees for a period not exceeding two weeks.

Assurance of continued activity of the business along lines prescribed by the charter gives assurance to investors and minimizes the hazards of investment. Those most directly concerned in the management of small corporations usually own a controlling interest and have a financial incentive to see that the company is efficiently managed. With the

demands of modern business for large amounts of capital, investors are provided with ample opportunity to participate in the profits which the organizing and administrative abilities of a lesser number make possible. In large companies the operating management may have but a small ownership interest. The directors of such companies may be chosen by minority groups, as many stockholders are chiefly interested in dividends and neglect to exercise voting rights. In some cases 10% of the voting stock exercises control of the corporation. Today practically all large businesses are incorporated, and most manufacturing firms with invested capital of $10,000 or more.

Where to Incorporate.—Small companies and those of medium size should usually incorporate in the state where they expect to locate and do the major portion of their business. Investor sentiment favors this action. The corporation laws of some states are notably weak and ineffective, and serve to attract companies of questionable repute. Other states have enacted liberal corporate legislation which is also sufficiently restrictive to safeguard the investor's interests. Factors to consider in choosing the place of incorporation are (1) incorporation fees and franchise taxes, which vary greatly, (2) liabilities of stockholders, (3) requirements as to meetings of stockholders and directors, and maintenance of an office, (4) reports required, (5) taxes on profits, and (6) extent of control vested in the board of directors. New Jersey may be cited as a state with fair and equitable laws regulating business. Delaware combines liberal corporation laws with low rates of taxation and attracts many corporations and much wealth as a consequence.

Promoting the Corporation.—Corporations grow out of other forms of enterprise, as partnerships, when they prove inadequate or unsuitable. They are also promoted by persons who recognize an opportunity for the establishment of a permanent business and seek to organize and set it going. In the former instances the rights and interests of the various individuals associated together are transferred into the new organization. This is accomplished by the granting of shares of stock, and by the choice of directors and administrative officers. In the latter instance the project may be initiated by those who expect to associate themselves with it, or by a professional promoter. The function of a promoter is to discover a project which has business possibilities, organize it, and arrange for financing. He is usually paid in cash and an allotment of shares in the enterprise. To protect the stockholders against unreasonable promotion expenses and costs, a state may limit such costs to, for example, 20% of the amount of stock subscribed.

Voting Trusts.—A voting trust is a device used to place the management and control of a corporation in the hands of a small group, usually during a period of reorganization. The arrangement may be desired by the banking interests who undertake the financing, or a management group which wishes to assure itself of control for the time necessary to carry out its plans and policies. In order to secure such aid the holders of a majority of the company's stock surrender the voting right of their stock to designated trustees in return for negotiable certificates. The holders of these voting trust certificates are entitled to any dividends paid during the time the voting trust is in operation. The trustees, or persons designated by them, will act as a majority on the board of directors in determining the policies of the enterprise. State laws usually limit voting trusts to a maximum of from five to ten years.

Holding Companies.—A more common means of securing control is by the formation of a holding company which owns all or a majority of the voting stock in several corporations. Most of our large corporations, such as General Motors, United States Steel, and American Telephone and Telegraph, are holding companies owning stock in many subsidiary companies. The holding company may be engaged in manufacturing on its own account, like General Motors, which operates all its automobile divisions; or it may be merely a device for ownership and coordinated control, like United States Steel, which does no manufacturing itself but owns many companies making and selling products under their individual brand names. Many smaller companies have taken advantage of the holding company device to set up separate manufacturing or sales agencies in other states or countries. The pyramiding of control by placing one holding company above another was used especially by electric and gas public utility companies in the 1920's. The abuses of this system became so apparent that the Public Utilities Holding Company Act was passed to correct the situation existing in that field. This law made it illegal to use more than one holding company above another for the purpose of controlling our public utilities.

Although the holding company has received much criticism, it serves a useful purpose among manufacturing firms. A large paint company may be engaged in several activities all related to the production of its principal product. It may have mines, dye works, pigment plants, refineries, and soy bean mills located in several different states. Local management is facilitated by separate incorporation, while centralized control is obtained by having one company own and vote the stock. Not all of the states permit a corporation to own shares in another, so holding companies are formed under the laws of a few states which have drawn their statutes to attract this form of organization.

"Blue-Sky Legislation."—The various states have enacted laws requiring official approval, usually by the Secretary of State, of security issues to be offered to the public. This requirement comes under the classification of "blue-sky" legislation, and is designed to keep fraudulent and worthless securities off the market. The Securities and Exchange Commission, established by Congress, endeavors to strengthen the state laws, protect the investor by providing against misrepresentation of securities offered for sale and manipulation of the market. The purpose of all such legislation is not to protect the foolish investor from his mistaken judgment but to prevent the exploitation of the public by stock sales through misrepresentation.

CHAPTER 6

ORGANIZATION FOR MANAGEMENT

Definition of Terms.—Before entering into a discussion of the different phases of management and the types of organization that are employed to obtain united and constructive effort, it is well to define some of the basic terms. Various writers have used these terms rather haphazardly, and some conflict exists in their employment. For example, "management" is often used to signify the control and ordering of others in some kind of activity. In this sense it is a general term that embraces both planning and guidance. In most business firms of any size there is a separation of these two duties. Hence, it is necessary to give a more exact description of what is taking place by employing the words with some restricted meaning. Although the terms are not entirely standardized, the definitions of Oliver Sheldon, an English writer, are considered authoritative in the field. Wisdom in administration, genius in organization, and operating ability have come to be increasingly important to the successful conduct of a business. Sheldon defines the terms as follows:

> Administration is the function in industry concerned in the determination of the corporate policy, the coordination of finance, production and distribution, the settlement of the compass of the organization, and the ultimate control of the executive.
>
> Management proper is the function in industry concerned in execution of policy, within the limits set up by administration, and the employment of the organization for the particular objects set before it.
>
> Organization is the process of so combining the work which individuals or groups have to perform with the faculties (mental and physical powers) necessary for its execution, that the duties so formed, provide the best channels for the efficient, systematic, positive, and coordinated application of the available effort.[1]

It is to be noted that administration, while manifesting itself to the greatest extent at the top of an organization, must nevertheless make itself felt in control and coordinative work in all parts of it.

Functions of Management.—The basic function common to all industrial companies, although differing in detail in various types of industry,

[1] Philosophy of Management, by Oliver Sheldon, p. 32.

is that of manufacture—the conversion of raw materials into articles for use by the application of skill and effort. In our modern plants, however, as Oliver Sheldon has pointed out, manufacture is but one phase of the general problem of management. His functions include preparation, production, facilitation, and distribution. The first of these has to do with the design of the product and the provision of physical facilities for making it. Production involves the actual manufacturing operations. Facilitation includes the problems incident to transport of materials and goods in process, planning, analysis and interpretation of production and cost data, and management of labor. Sales planning and sales execution come within the scope of distribution. It will be observed that the functions indicated above mark natural and specialized divisions of effort. The performance of each function will call for the employment of a group and probably the exercise of several different faculties, as executive, advisory, and operative. One person may exercise several faculties.

Faculties Required in Management.—The faculties indispensable to good management are charted in Figure 8. The feature of this chart is specialization. The activities engaging the attention of individuals with particular titles are indicated, as well as the major faculty exercised. Thus the manager exercises chiefly the executive faculty, but he is an administrator in so far as he coordinates local functions and determines local policy. The service group acts like a bureau of business research in carrying on investigations, compiling, analyzing, and interpreting data from which conclusions of value to the business may be drawn. It acts strictly in an advisory capacity. The consultative faculty is provided by particular individuals, members of the plant personnel, or advisers from the outside, working through committees, conferences, and employee-employer organizations.

It must not be inferred that managerial faculties may be, or are, circumscribed by positions held; positions merely indicate the major faculty exercised. It is all-important that every individual, irrespective of position or title, exercise managerial faculties to the extent of supplementing and completing the work of others. The operator must manage his work, his machine, his tools, to best advantage. That all engaged may contribute ideas of worth to the business is recognized by the inclusion of all faculties in the consultative group.

Management Problems Fundamentally the Same.—"A locomotive company may appear to have but little in common with a dairy. A lumber yard may seem to have but little in common with a department store. The problems of all, however, resolve into five groups: Problems of policy, organization, personnel, facilities, and methods. Proper solu-

tions to all the important problems in these categories serve to produce an effective business.

"Results do not simply happen. They are the offspring of causes. The business executive who deliberately increases the effectiveness of a

THE FACULTIES OF MANAGEMENT

	Faculty	Title	Description
Consultative	(1) Determinative	Board of Directors	Determination of Policy
	(2) Administrative (a) Administrative	Managing Director	General application of policy: coordination between functions; control of executive.
	(b) Sub-Administrative	General or Group Manager	Detail application of policy; control of functional groups.
	(3) Executive (4) Service (a) Executive	Manager	Departmental supervision; local coordination of functions; determination of local policy.
	(b) Sub-Executive		
	(c) Supervisory	Sub-manager	Detail application of main executive directions; sectional supervision.
		Foreman	Immediate supervision of work and leadership of workers.
	(a) Investigational	Specialists	Investigational work, methods, appliances, rates.
	(b) Co-ordinative	"	Secretarial, statistical recording, comparative treatment of data.
	(c) Advisory	"	Synthetic presentation of investigated data.
	OPERATIVE (a) Technical (b) Clerical (c) Craftsmen (d) Semiskilled (e) Unskilled (f) Apprentices		Manufacturing and functional operations.

Figure 8. Faculties of Management

(From Philosophy of Management, by Oliver Sheldon, p. 66.)

business by logically considering his problems and fitting their solutions into an effective whole is as much a designer as any architect." [2] The fundamental sameness of all business explains the success which an able

[2] From an editorial, "Business and Art," by Caleb, in Marshall Field & Company's column, "Moving Forward," in the *Chicago Tribune*.

executive may enjoy in diverse fields. However, the fact that every business enterprise is individually different and with a varying human element precludes organization and management by common rules. Science plays an increasing part in the conduct of business, but it will always remain in part an art.

A Check Upon Good Management.—A test for the effectiveness of the management in any enterprise is given in Figure 9. Superior performance in connection with each of the management principles is desirable and may be essential if the company is to prosper.

THE MANAGEMENT PRINCIPLE	THE SUPERIOR FIRM	
I. INFORMED LEADERSHIP	1. Weekly or Monthly Reports from all Divisions—Production, Sales, Executive and Financial Showing (A) What Should Have Been Accomplished (Standards). (B) Variances of Actual Performance from Standards. 2. Budgetary Control Over All Expenditures. 3. Forecasts Showing Future Trends.	10
II. SOUND ORGANIZATION	1. Organization Set-Up Clean-Cut and Definite. (A) Fixed Responsibility. (B) No Overlapping Authority. (C) Complete Coordination Between All Departments, Especially Between Sales and Production. 2. Centralized Personnel Management. 3. Organization Chart Covering Both Personnel and Functions. 4. Development of Understudies for Executive Positions.	10
III. BALANCED FINANCIAL STRUCTURE	1. Adequate Liquid Investments to Meet Exigencies. 2. Funds Available for Making Advantageous Purchases and Taking Discounts. 3. Current Ratios including Inventory Controlled by Use of Budgets. 4. Financial Provisions for Replacing Depleted and Depreciated Assets. 5. Excess and Idle Capacity Carefully Measured.	10
IV. PROPER MARKETING OF PRODUCT	1. Complete Market Analysis Periodically Showing Actual vs. Potential Sales by Lines of Product, by Territories and by Salesmen. 2. Sales Efforts Analyzed, Controlled and Directed to Obtain Maximum Results from Effort Expended. 3. Sales Analyzed on Basis of Profit Realization. 4. Customer Service Made Important Function.	10
V. EFFECTIVE PHYSICAL EQUIPMENT AND LAYOUT	1. Modern Machinery Provided. 2. Layout Takes Advantage of Synchronized Progressive Line. 3. All Production On a Standard Time Basis. 4. Excellent Maintenance Provided, Keeping Equipment in Standard Condition. 5. Repairs Carefully Recorded and Standards Set.	10
VI. SIMPLE ADEQUATE RECORDS	1. All Unnecessary Records Eliminated. 2. Records and Reports Meet Specific Needs of Those Who Use Them. 3. Modern Mechanical Bookkeeping and Statistical Methods Used. 4. Records and Timely Reports Covering Products and Performance. 5. Accounting and Costs Parallel Lines of Organization. 6. Proper and Adequate Filing.	10
VII. THE DEVELOPMENT OF STANDARDS	1. Standard Costs Wherein the Accounting System Portrays Required Performance Rather Than Merely Recording History. 2. Variances from Standard Reported Daily, Weekly or Monthly. 3. Variances Subjected to Follow-Up Program. 4. Overheads Controlled by Flexible Budgets With Definite Responsibility. 5. Constant Study and Revision of Standards.	10
VIII. MEASURED INCENTIVES	1. Direct Labor Controlled by Incentives Based Upon Performance Standards. 2. Sales Incentives Provided for Sales Effort Covering Both Volume and Profit Realization. 3. Key-Man Bonus Established for all Supervisors. 4. Executive Compensation Plan for Top Executives. 5. All Bonuses Related to Super-Performance and Specific Savings.	10
IX. ADEQUATE RESEARCH	1. Constant, Planned Research Covering (A) Merchandising Methods. (B) Management in All Its Phases. (C) Production. (D) Design of Product. (E) Possibility of New Lines and New Outlets for Old Lines.	10
X. RELATION WITH YOUR INDUSTRY AS A WHOLE	1. Takes Active Part in Trade Association for the Industry. 2. Helps Establish and Maintain Fair Trade Practices. 3. Assists in Building Uniform Accounting Records for the Whole Industry. 4. Helps in Building Balanced Program—Production With Consumer Demand. 5. Complete Cooperation With Code and Code Authority.	10
SCORE	TOTAL	100

Figure 9. How Good Is Your Management?

(From "How Good Is Your Management," by Charles Reitell, *Factory Management and Maintenance*, Vol. 93, No. 1, p. 11)

CORPORATION CONTROL AND ADMINISTRATION

The Stockholders.—The stockholders are the owners of the company. Owners of common stock participate in profits only after other financial obligations of the company have been met, including dividends to preferred stockholders. The latter group receive dividends, if earnings permit, at a rate stipulated in the stock certificates. Sometimes cumulative preferred stock is issued, which obligates the company to accumulate earnings and pay the dividend rate specified before paying dividends to common stockholders. Thus if in years of poor business earnings were not sufficient to pay regular dividends to preferred stockholders, deferred dividends would be paid out of subsequent earnings before payments are made to common stockholders. In event of large profits the common stockholders are in an advantageous position, receiving all profits remaining after other company obligations are met. There are various classes of stock issued in addition to the ordinary kinds mentioned. Not all classes of stock have voting privileges, but usually owners of common and preferred stock have this right granted by state statutes.

Corporation stockholders in many cases are not interested in, or are careless with respect to, voting rights; being chiefly interested in anticipated dividends. When stockholders do not appear at meetings, or are not represented by proxies, management control may be exercised by a relatively small proportion of the ownership. This situation may result in a company being operated mainly for the benefit of a particular group rather than the average stockholder. In a few cases stockholders elect auditors who report directly to them, or choose a committee to name such auditors.

The Board of Directors.—The board of directors is chosen by vote of the stockholders. Within the limits of the charter granted by the state, it directs the activities of the corporation by establishing basic major policies for production, marketing, financing, and public relations. It also chooses the chief executive who is to administer direct control of the organization, and appraises the results of his efforts. The board also chooses the other officers, such as the secretary and treasurer. The president will usually secure the approval of the board to the appointment of all major executives he selects and who report to him.

A committee of the board may be designated to which matters coming before the board are first submitted for study and recommendation. The same or another committee may be empowered with executive authority by the board to act for it between board meetings.

Boards of directors will ordinarily include from five to nine members, never less than three, and with large companies sometimes as many as

twenty-five or more. They will usually include the president of the company and one or two other major executives such as the treasurer and secretary. Other members will be important stockholders and those whose wisdom and counsel are desired in administering the affairs of the enterprise. In many instances individuals are elected to board membership because of their knowledge and influence in other fields.

The President.—The president is the responsible, acting head of the enterprise, selected by the board of directors to carry on the business in accordance with the general policies established by it. He is responsible for the organization of the plant and its successful management. With the cooperation of his immediate subordinates through the medium of a plant executive committee, he will formulate operating policies, and coordinate and control the activities of the business as a whole. Like the captain of a ship who must take wind and weather into account, the president must exercise vision and display wisdom and judgment with respect to external, but very important, social and economic forces. For intelligence with respect to internal problems of management he may depend largely upon his executive staff.

In many small and medium size companies the president's perspective of general conditions and his intimate understanding of the industrial situation qualify him to guide the board of directors in their deliberations. He may be the dominant force in bringing about decisions with respect to policy. Experience indicates the wisdom of freeing the chief executive of a large organization from managerial activities in order that he may devote the major share of his attention to outside factors which manifest themselves in price fluctuations, a varying volume of business, changing property values, market trends, and public and governmental relationships.

The General Manager.—When the inclusion of a general manager as a member of the staff is warranted, he functions as the right hand of the president, with authority and responsibility for plant operations in their entirety. As the chief of all departments he is largely instrumental in selecting those in charge and in shaping the organization, and will be responsible for methods and processes. Guided by the policies of operation determined upon by the plant executive committee of which he is a member, he exercises a governing influence in securing effective teamwork from departments and individuals. Maintaining a balance and cohesion in large companies, keeping abreast of the times in manufacturing technique and procedure, and providing the personnel with a constructive and inspiring leadership will engross the time of one individual. When these complex and urgent duties have to be handled by the presi-

dent along with his other activities, they tend to absorb too much of his time. As they require talents quite different from those required for external affairs, there is further reason for handling them separately.

The number of department heads reporting to the general manager will vary, but usually it is not more than five or six, and may be less. Duties of officers and of department heads vary in different organizations.

The Secretary.—The secretary is usually a member of the board of directors but not necessarily so. He is the company officer who calls meetings of the stockholders and board of directors, prepares agenda for such meetings, and keeps the minutes. Other responsibilities include keeping a record of stockholders, of stock transfers, and making reports to stockholders. The secretary's signature is required on legal papers, and he maintains close contact with legal actions affecting the corporate interest. In smaller organizations he may be assigned duties in addition to those pertaining strictly to the office of secretary.

The Treasurer.—The formulation of financial policies and general control of financial matters comprise the responsibilities of the treasurer. He receives and disburses company funds, pays taxes, insurance, and, as instructed by the board, dividends. He is also responsible for the procurement of capital; and for the purchase and sale of company property, including both real estate and securities. The treasurer keeps custody of company funds and legal papers having financial importance, such as contracts, leases, insurance policies, patents, notes, bonds, and the like.

The Comptroller.—The comptroller is responsible for the methods and procedures involved in financial and statistical record keeping. He will have charge of general accounting, cost accounting, statistical analysis, auditing, and perhaps credits and collections. In some organizations this latter function is assigned to the treasurer. Particular phases of the comptroller's work include inventories, timekeeping and payrolls, tax reports, and forecasts and budgets. Management of the general office is frequently another of his duties.

The comptroller, because of his broad perspective and opportunity for intimate understanding of all phases of company activity, is in a key position and may become a valuable aid and adviser to the administrative officers—an important executive. As a recognition of this fact he not infrequently reports directly to the president, and sometimes to the board of directors. Although having direct control over his own department group, and of methods and routines of record keeping throughout the organization, he functions otherwise as a staff officer, providing knowledge and information through reports.

The Superintendent of Manufacturing.—The executive in charge of manufacturing has the responsibility for production (utilizing the facilities provided), for facilitation of production, and sometimes for preparation for production. In addition to the manufacturing operations in the machine shops, woodworking, painting, and assembly departments, certain auxiliary services are required. These include production planning, plant engineering, industrial engineering, quality control, stores control, and tool control.

The term production planning embraces planning of manufacturing orders, scheduling operations, and dispatching or issuing work orders. Plant engineering includes power plant and maintenance services, fire protection, watchmen, and guard service. Industrial engineering includes the determination of proper layouts and working arrangements, such as machines, tools, and the like; also time and motion analysis, job standards, labor classification, and wage determination.

The Industrial Relations Executive.—Industrial relations, or personnel, management has merited and received increasing attention due to the social and economic problems revealed among the rank and file during depression years, the requirements of social security legislation, labor disturbances engendered by labor leaders, and the introduction of national and state politics into labor relations. "The director of personnel work is essentially in a staff capacity. He is responsible for the initiation of industrial relations policies, for the approval of management and for keeping management informed regarding new developments in the field of industrial relations applicable to his organization. He is responsible for putting policies into effect, and for insuring the same attention to them on the part of operating departments as is given to other expense factors such as machines and materials; for the responsibility for specific results must of necessity rest with the supervisors of the operating departments. . . . He should be familiar with the sales, production, and financial profit points of view so that he may work intelligently with these departments for the greatest prosperity of the business. In this way he can make personnel management an essential feature of good management." [3] Personnel work is discussed in more detail in later chapters.

The Purchasing Executive.—The purchasing function varies with the industry and size of the company. Depending upon these circumstances it will be organized independently as a separate major depart-

[3] "The Personnel Director," Bulletin No. 9 in a series dealing with business organization, Policyholders' Service Bureau, Metropolitan Life Insurance Company, New York.

ment, or occupy a subordinate position as in the manufacturing department. Its work will include buying and follow-up of orders, research and investigation in connection with materials and products purchased, a clerical and records division, and perhaps salvage and traffic divisions. The disposal of scrap and of old or unwanted equipment is usually handled by the purchasing department. When purchasing is carried on by the manufacturing department it may be combined with control of storerooms and traffic management.

The Sales Executive.—The task of the executive in charge of marketing operations is divided into two parts—sales and advertising. Sales administration requires the building up and direction of a sales force, market research, and perhaps sales promotion activity. The type and details of organization depend upon the nature of the product, upon the number and variety of sales items, their value; whether sale is to the user, or through retail, wholesale or jobber outlets, the class of trade called upon, and other factors. Advertising efforts include the formulation of advertising policies, preparation of copy, distribution of advertising material, and agency contracts. "A very important part of the advertising manager's job is periscopic in character, consisting in the constant review of advertising media and advertising plans, the study of market opportunities, trade movements, and style trends, the character of competition, the appropriate line of appeal. This phase of his work consists of thinking rather than doing." [4]

The Engineering Executive.—The engineering department designs the product or products manufactured, and has the responsibility for keeping them up to date. They also provide the manufacturing department with specifications, drawings, and supplementary data, such as parts lists, needed to facilitate manufacture and insure satisfactory quality. Design, research, and experiments and tests are logical divisions of the work of this department. In some large organizations the engineering executive has the additional responsibility of determining the manufacturing requirements of new or changed products with respect to layouts, machinery and equipment, tools, labor, and costs. Production may be actually established on a satisfactory operating basis before being turned over to the manufacturing executive. In other cases much of this production or industrial engineering work is a function of a division of the manufacturing department.

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[4] "The Function of the Advertising Manager," Bulletin No. 5 in a series on business organization, Policyholders' Service Bureau, Metropolitan Life Insurance Company, New York.

The Heads of Sub-departments.—The heads of production departments in present-day concerns are chosen particularly with reference to their specialized knowledge, their powers of leadership, and their willingness to accept cooperation and to harmonize their work with that of others. They are entrusted with the detailed application of policy and with responsibility for phases of technical achievement, to the extent called for by general plans. Together with assistants the department heads formulate department policies in harmony with plant policies and see that they are executed.

It will be noted that those who are concerned in the making of policies are also responsible for putting them into effect. Heads of service and auxiliary departments are, of course, specialists commissioned to bring to the actual manufacturing departments the most effective instruments of production with respect to personnel, tools, production control procedure, wage plans, standards, transportation, and so forth. Functional organization of these contributory departments, combined with specialized departments for manufacturing according to processes or operations, has greatly increased the industrial efficiency of the plant.

Supervisors or Foremen.—Specialization and functional control have limited the sub-executive's duties. The service and auxiliary departments enumerated in the preceding paragraph concentrate, in his behalf, managerial skill, service, and operating information. Nevertheless, he cannot be dispensed with. Functional services and systems, though they may be complete, cannot be perfect, and there are always exceptions to established procedure. The foreman provides the necessary human element at the point of contact to make adjustments, rectify errors, remedy deficiencies, interpret and administer instructions, make reports, supervise work, and, most important of all, provide personal leadership. In the final analysis the foreman is responsible for output. He is a manager, a teacher, a leader. As the farthest outpost of management, he *is* management to the workers. One firm with over 30,000 workers instructs foremen to devote fully 50% of their time to "knowing your men." Understanding brings cooperation and with it a greater output than can be achieved through "fear" or "drive."

The number of workers assigned to a group leader will vary, but probably the most common practice is to have from 8 to 15. With simple operations a greater number may be included. From 5 to 10 group leaders may report directly to one sub-executive. The more effective leadership and control possible with such small units justifies the greater expense.

VARIOUS PLANS OF ORGANIZATION

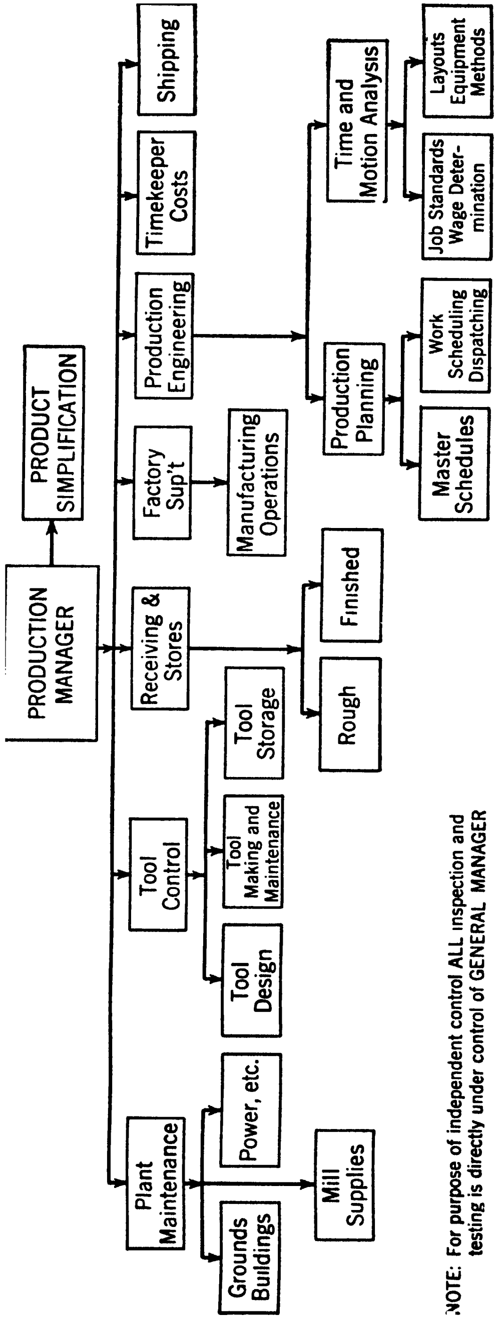
With the growth of industry several distinct organization types have been evolved, each with its particular merits. They will be analyzed separately, although in practice two or even several forms will be found combined in a single organization structure. The organization plan will vary according to the character of the industry, the size of the concern, the abilities of the available personnel, and the ideas of the management.

The Departmental Plan.—The first tendency in organization, as plants became larger, was to divide establishments into departments according to processes or products. With some exceptions, each department head became virtually the head of an independent establishment. He was responsible not only for actual manufacturing, but for planning, personnel, production control, provision and use of equipment, costs, records, research, inspection, and purchasing. As the number of departments increased, authority and responsibility for various phases of the supplementary activities became intricate. The result was a duplication of organization and management efforts on the part of the various departments, with consequent high costs, conflicting policies and lack of coordination. For example, differences in wage scales within a plant were common. With a variety of duties to perform there was little opportunity for management to plan for growth and development. Routine operations absorbed time and attention. Inevitably some phases of management were neglected, others poorly administered.

In present-day plants when authority for the production of a product or the carrying on of a phase of manufacturing activity is vested in a particular executive, there will be a separation of planning from performance, and aid will be given in making long range plans. This means the providing of specialized functional and staff services. Their presence marks the distinction between the old and the new kind of management; and the difference between ineffective and effective organization.

The Functional Type of Organization.—As suggested in connection with the departmental plan, some functions come into play in several divisions of the business, or in all of them. The best illustration of this is industrial relations activity; others are standardization, works engineering, research, inspection, purchasing, transportation, and the like. The idea of functional control is to provide specialists in executive positions with control of particular functions or phases of activity in all departments.

As functionalization is increased, responsibility is decentralized and the scope of authority and control permitted to the departmental execu-



NOTE: For purpose of independent control ALL inspection and testing is directly under control of GENERAL MANAGER

Figure 10. Organization Chart and Functions of a Production Department

tive is narrowed. Greater expertness and intelligence accrue from specialization; there is less likelihood of neglect or poor administration of any function, and progress should take place in all lines because of the concentration of individual interest. As functional activity is extended, the department heads are enabled to concentrate on execution, to perfect their organizations, and to give better supervision. To be successful the activities of the functional departments must be well coordinated and kept in balance by the executives in charge. This may be accomplished by means of committees.

The pendulum must not be permitted to swing too far in the direction of eliminating local authority in favor of functional, detached control. Uniform policies and practices are essential, but general counsel and advice given to those in direct charge may suffice. Authority granted to supervisory employees may strengthen control rather than weaken it. The tendency to return full responsibility for the performance of subordinates to the supervisors indicates a realization of the dangers of extreme functionalization. Functional control must not take away the real authority required to get results. Authority is motive power. Figure 10 shows a natural division of functions in a production department. The personnel may be organized in each department along vertical lines, but service—as for example, in the case of the plant maintenance department —is performed by one group for all. Functional foremanship in the shop, a continuation of the plan in the lower ranks of the organization, will be discussed separately.

The Line Plan.—The line plan of organization is probably the one most frequently employed by small manufacturing companies. Instead of dividing activities according to the products made or sold, as is done in the departmental plan, the divisions in this case are broken down according to the various classes of work to be accomplished. Each department is engaged in promoting one major function, but the control has not yet become functionalized. It is a step from the departmental arrangement toward functionalization, but authority is still restricted to definite divisions of the personnel. The line plan is often referred to as the military type of organization, for authority over the various sections is direct and supreme in its field. There is no overlapping of authority. At the head of the organization is the owner or president as the case may be. Like the general in an old-time army he has supreme command and all subordinates are responsible to him. His lieutenants are the heads of the manufacturing department, the sales department, the accounting department, etc. Each department is divided further according to its size and work.

The outstanding characteristic of the line plan is its direct control and authority. It is said that here authority flows in a straight line, and hence the plan gets its name from this feature. There is no question where responsibility lies, for all the subordinates report to their respective chiefs and to no others. This is an admirable type of organization for small companies, but when large size is achieved it becomes difficult to obtain men with sufficient knowledge and force to take care of the numerous details that must be handled. A small chart of the simple line plan is shown in Figure 11.

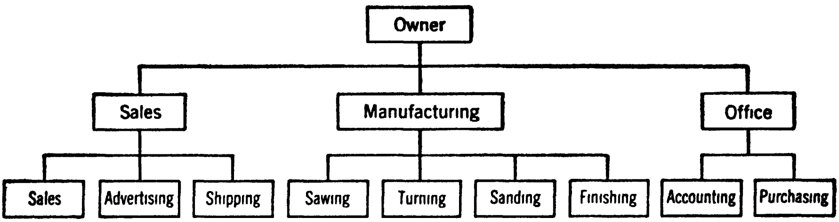


Figure 11. Line Plan of Organization

The Line and Staff Plan.—In this form of organization there is a line or departmental organization for doing the actual manufacturing, and a supplementary staff organization acting in an advisory and investigating capacity. The first group exercises the faculty of leadership in getting things done; the second provides information as to ways and means. This latter group is made up primarily of thinkers—scientists, engineers, and executives skilled in method and procedure, who bring expert intelligence and skill to bear on each problem. They are concerned with making analyses, doing research and investigating work, planning and coordinating information to be made available to line executives. The chief function of the staff is to analyze and point out the road to business efficiency. The task of attaining the ideals pointed out is the function of the line.

The plan offers a clean-cut division of effort, separating the routine from the non-routine work of production, and separating planning from execution. As individuals are seldom equally talented in both planning and execution, abilities are utilized to better advantage. Flexibility is possible in that a line executive may perform work of a staff character at times in conjunction with his regular duties. Likewise a staff man may be assigned executive duties at times, as in putting into operation ideas and plans which he may have developed and which have received proper approval. Of course there should be close cooperation between the line and staff at all times.

The frequent occurrence of new and unusual problems makes staff assistance valuable; when they do not arise, such assistance is less essential.

Figure 12 illustrates the line and staff type of organization. The president is served by staff advisers: an economist, a statistical department, and a legal department. The general manager has available a staff service, consisting of an industrial engineering department and a research and experimental laboratory. It will be noted that the staff departments have no direct control over production, nor do they exercise any executive authority. In the line part of the organization the lines of authority

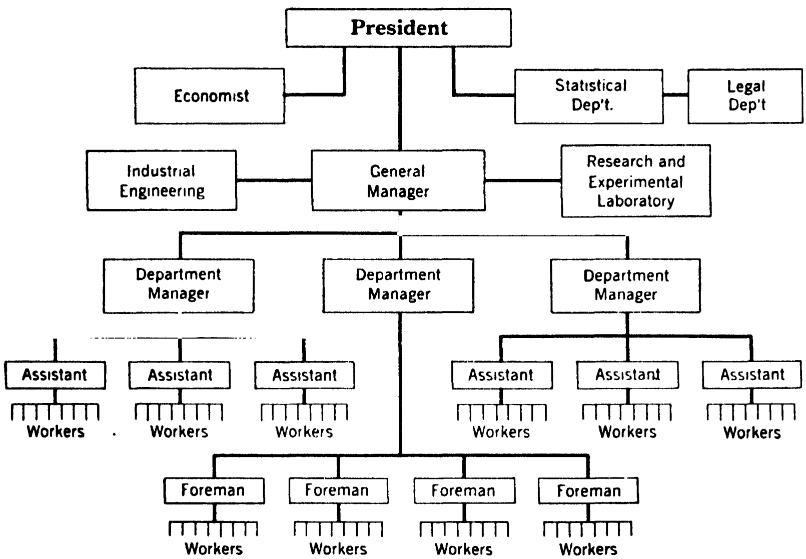


Figure 12. Line and Staff Organization

and responsibility are vertical. The workers in any group are responsible only to their group foreman, the foreman to his department manager, and the latter to the general manager. The general manager is responsible to the president. The path of authority is in the reverse direction. Individuals on the same level in the line part of the chart, whether department managers, foremen, or workers, are independent of each other in respect to authority and responsibility. No foreman may give orders to the men in another group.

In organizations of large or medium size a feature of line control may be a lack of sufficient coordination of departments. A further weakness is that a single individual has to perform both staff and executive tasks.

In smaller concerns the closer personal touch possible assures better cooperation among subordinates.

The Committee Plan of Organization.—Strictly speaking, a business cannot be managed by committees, but they may be so numerous and influential in an organization as to stamp it of the committee type. This form of organization has definite weaknesses, however, which have lessened the enthusiasm for committees as a medium for general executive control. The committee form of organization is usually found to be dangerous, since most such committees waver between the extremes of gross assumption of authority by some members and a disclaiming of authority by all members. This results in preventing both workers and outsiders from securing either quick decisions or effective action on questions of policy. Numerous committee meetings take much time, often get nowhere, result in ineffective compromises, or enable majority opinion to prevail over proper courses of action. But in spite of these shortcomings of committees, the committee is a most valuable supplementary service in other forms of organization.

Some companies report that the group management idea is an excellent device for training and developing managerial talent. With this idea in mind one organization created additional places on its board of directors for younger men, and established a dozen or more important committees. These include a Research and Control Committee, Products Planning Committee, Budget Committee, Finance Committee, Suggestion Committee, Study Club Committee, the Medical Committee, Personnel Committee, and the Legislative Committee. "Careful minutes of all Committee Meetings are kept and reviewed by the executives. Recommendations are made and approved or disapproved by the executive committee." [5]

Executive Committees.—An executive committee may decide matters brought before it, although it cannot take action, for definite lines of authority must be retained by individuals in responsible executive charge. Such a committee brings a wide range of intelligence to bear upon a given problem, coordinates the views of those interested, and secures greater cooperation in carrying out the decisions reached. Executive committees provide a way of utilizing the wisdom and judgment of officials in matters ordinarily outside their jurisdictions, and often enable the chief executive to strengthen and guide a weak department indirectly and impartially. All this is a definite aid to management.

[5] Group Management, by S. DeWitt Clough, President, Abbott Laboratories, North Chicago, Illinois, Monthly Bulletin, Illinois Manufacturers' Costs Association, No. 140.

Further benefits are the closer association of executives, resulting in improved morale, and the broad-gauge training provided.

Advisory Committees.—The personnel of advisory committees should be selected with reference to the particular need. They are intended to bring together those best qualified to advise in particular matters, and thus exercise a staff function. Usually the personnel should be limited to from four to seven, or the work should be handled in part at least by sub-committees. The executive in whose service the committee acts will be the logical chairman. While the decisions are not necessarily binding, if the committee is functioning properly its recommendations will be used as a guide for action. As executives may always counsel informally with others in the organization, the advisability of formal committee organization in many instances may be questioned. It is easy to overorganize. When this happens the cost is considerable, there is a bad effect on morale, and a waste of much executive time.

Coordinative Committees.—In a business of any size, committees provide the chief instrument for producing teamwork and coordination of viewpoint. The larger the organization the more essential they are to unity of action. All committees are in a sense coordinative in that they disseminate a common understanding among the personnel, promote harmony, and lead to balanced effort with one definite purpose in mind. In a functional form of organization they are absolutely necessary.

Good examples of coordinative committees are the Plant Executive Committee and the Inter-departmental Committee. The former functions for the various types of manufacturing activities while the latter is used principally in the general office.

Informal Coordination.—In larger organizations there is a marked tendency to build up cross relationships to supplement the vertical lines of responsibility and authority. These relationships may not be shown on charts, for they are, in fact, informal. Nevertheless, they are the lines upon which action will normally be taken. Problems which affect several departments may be settled by agreement of those immediately in charge, rather than those above. In purchasing, for example, the purchasing executive may have in mind specification changes which will favor better buying. A conference with the production and engineering heads should be sufficient. Or, in a matter of providing customer service, the sales, production control, and manufacturing departments may well get together. If the matter cannot be settled, the general manager may be asked to make a decision. The development of cross relationships diffuses management; it implies the presence throughout an organization

of managerial talent, which can and should be utilized. Coordination is achieved more easily by this mental interlocking of groups than by action along vertical lines. "You cannot always bring together the results of departmental activities and expect to coordinate them. You must have an organization which will permit interweaving all along the line. Strand should weave with strand, and then we shall not have the clumsy task of trying to patch together finished webs." [6] It is difficult to show this kind of management structure on a chart. It is a living force rather than a mechanical arrangement.

Special Purpose Committees.—These may be permanent in the organization or may be created to fill a temporary need. Examples of the latter type would be committees appointed to take charge of arrangements for moving into a new plant, to consider adding new items to the line of plant products, or to investigate the advisability of establishing a branch plant. A committee on manufacturing methods should be permanent and should have as its personnel the production superintendent, the individual in charge of equipment and methods, and various foremen. If the factory manufactures on customers' orders, the production superintendent may head a committee including various shop foremen, and representatives from the planning room and order department, who confer daily with regard to schedules and delivery dates. A committee on safety is usually permanent. Cost committees, likewise, need continuity to prove most useful. In all committees it is essential that the members have an interest in the results to be accomplished. Hence the membership is made up of men from the departments directly affected.

FORMS OF SHOP ORGANIZATION

The Military Type of Shop Organization.—The characteristics of the line or military type of organization have been indicated in the discussion of that plan. The chief virtues of a shop organization of this character are its simplicity, the clear-cut lines of authority and responsibility, and the effectiveness with which discipline may be maintained. On the other hand, there are serious, inherent defects. Frederick W. Taylor's analysis of the plan as it operated in the machine shop of the Midvale Steel Company in 1881 pointed out the burden it placed on the foremen. Each gang boss was expected (1) to be a master mechanic, (2) to be capable of reading and interpreting drawings, (3) to possess ability to plan work ahead, (4) to stimulate high output of product of proper quality, (5) to set piece rates and adjust wages, (6) to maintain

[6] "The Illusion of Final Authority," by Mary P. Follett, *Bulletin of the Taylor Society*, Vol. 11, No. 5, p. 243.

discipline, (7) to hire new workers, and (8) to provide the general executive control, supervision and personal leadership demanded.[7]

Taylor rightly concluded that a man endowed with the qualities needed to make a good gang boss would qualify as a works manager. The responsibilities placed upon such a man were varied and urgent, precluding progress in methods and procedure, or expertness in even one particular. As a result, the individual workmen were almost entirely "on their own," the foreman's time being occupied with general duties. Control was ineffective and standards of production low.

Taylor's experience was in one of the first of the big shops in the metal trades industry where production was a complex procedure. In other industries, however, the situation was similar if not quite so serious. The organization and methods of the little shop had been carried into the big shop, the volume of work and responsibility being simply subdivided on the departmental plan. Each foreman held sway in his area in about the same way as did the proprietor of a small shop. Ways and means of accomplishment were matters to be solved by the workmen at their machines. These were much less specialized than now, less perfect, with little data as to best speeds, feeds, and methods of operation of work, piece rates, employment, training of workers, discipline, the provision of tools and accessory equipment, quality and quantity of output, and shop procedure. Control was impossible and gross inefficiency inevitable.

Taylor's Plan of Functional Foremanship.—In an effort to operate his machine shop more effectively, Taylor evolved the functional plan of foremanship. The foreman's work was divided into eight parts, with specialists in charge of each division. Figure 13 illustrates his plan.

Planning was separated from performance by placing four of these specialists in a planning room or office. Direct charge of operations was placed in the hands of the four in the shop. Each of these eight individuals had authority over the workmen with respect to his special function. The worker would have little actual contact with those in the planning room, control being exercised through the medium of work tickets, instruction cards, piece rate cards, etc., which were issued to him with each job. The duties of the eight bosses are indicated by their respective titles as follows:

In the planning room the order of work and route clerk was to determine the jobs which should have precedence and the route they were to follow through the shop as they were being processed. The instruction card clerk made up and issued the instruction cards which indicated to

[7] *Transactions of the American Society of Mechanical Engineers*, Vol. 24, p. 1389.

each workman the nature of the particular job and the details of its accomplishment. The time and cost clerk determined the time necessary to complete the job and the costs entailed. He was concerned with obtaining this information from the men in the shop and then making the results available to management. Since Taylor's plan removed the direct authority over the workman exercised by the line foreman, it was evident that discipline would be lax. In order to obviate this drawback the disciplinarian was included. His duties were to check insubordination, keep records on the workmen and bosses, and maintain harmony in the shop—much on the order of a modern personnel manager.

In the shop the gang boss had charge of the preparation of all work up to the time that the piece was set in the machine and the operator was ready to begin work upon it. This included getting together the needed auxiliary equipment, tools, drawings, and seeing to it that a job was

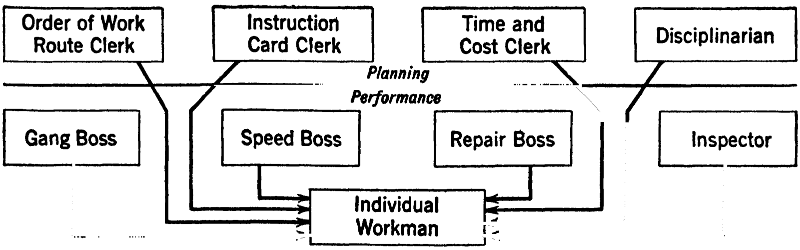


Figure 13. Functional Foremanship in the Machine Shop
(From Applied Motion Study, by Frank B. and L. M. Gilbreth, p. 27.)

available for the worker when he completed the one on which he was engaged. The function of the speed boss was to see that the worker performed the task in the proper manner, and, if necessary, to demonstrate that the method and time outlined on the instruction card were correct. The inspector was responsible for quality. In many cases he would observe the worker while completing the first unit, approving both methods and finished work before the task was continued. The repair boss gave attention to proper use of equipment, its care and maintenance.

Thorough standardization of shop equipment, tools, and methods was a necessary accompaniment of this plan and was accomplished by Taylor. As a consequence, task times could be set with assurance.

The advantages of functional foremanship lie in the greater efficiency arising from specialization in managerial effort, the certainty of a more balanced administration of functions, and the relative ease with which men who are qualified in one or two functions may be secured. The grade of directing intelligence available to the worker is greatly increased,

and made equal in all phases of his work. As disadvantages, there are the tendency toward weakening discipline, possibility of conflicting authority, and difficulty in maintaining proper coordination of functions.

Present-Day Shop Organization.—Taylor's functional and standardization ideas have received universal acceptance, though the manner of application varies in different shops and industries. Taylor's plan, as outlined, is not in use today in the original form. The essential thought is kept but the weaknesses have been eliminated. In all cases planning is definitely separated from performance, and the responsibilities of the foremen have been steadily decreased in number. As examples of this, separate administration is the rule with respect to production control, standardization work, tool room administration, setting of time standards, personnel, and training of the workers. The foreman's work is further simplified by the improvement and specialization which has taken place in equipment manufacture, narrowing the range of work for the individual operator and making it easier to perform.

The Caterpillar Tractor Co., while adhering to Taylor's ideas, has found it possible to simplify the shop organization. The speed boss has been eliminated, and quality control of all manufacturing operations is centered in a separate functional organization. When a man is assigned a job in the machine shop, the tool room is notified, and makes ready for his use the necessary tools and auxiliary equipment needed, if they are not already available at the work station. He secures these at the tool room window after receiving his labor ticket.

> The reasons for the passing of the speed boss are chiefly that the standardization of methods and the improvement in machinery have rendered him unnecessary. . . . If the workman has difficulty in accomplishing his task, the foreman is required to assist and demonstrate, if necessary, the methods called for by the instruction card. . . . The duties of the gang boss which still remain are discharged by the foreman in charge of each group of workmen. These duties comprise general oversight of the work of the men, including the setting up of their machines. . . . Foremen are encouraged and required to assist their men at all times to the end that they may become better workmen. . . . The original function of repair under the "repair boss" is now the plant engineer. . . . Today the personnel department has all the duties of the old disciplinarian and many more.[8]

In those establishments where the operations performed are repetitive, and where as a consequence the machines are specialized, the efficacy

[8] "Building Tractors Under Scientific Management," by G. D. Babcock, *Management and Administration*, Vol. 8, No. 2, p. 141.

of functional foremanship diminishes. With preliminary training an operator becomes skilled in operating his machine and needs little further guidance. In many industries the "set-up" of the machine, and arrangements for proper speeds and feeds are built into the machine itself, and even control of quality is largely inherent in it. Examples are woodworking machines, punch presses, textile machinery, sewing machines, knitting machines, etc. In many cases inspection of each operation is unnecessary, because defective work will be noted by succeeding operators and checked at assembly stations or at established inspection points. Many operations are performed without the use of machines. In the great majority of shops, therefore, a group of operatives are directed by a line foreman or supervisor whose function is chiefly executive—getting work done according to schedules, with plans and arrangements provided by others—in other words, giving effect to the work of the various functional departments.

CHAPTER 7

CHARTING THE ORGANIZATION

Organization Charts.—Organization charts represent attempts to portray the responsibilities, duties, and activities of the personnel in carrying on the particular business represented. They show relationships between individuals, define authority and responsibility, indicate logical paths of promotion, prevent tendencies toward overlapping of activities and duplication of functions. They provide a clear-cut perspective of the business as a whole by showing what activities are carried on, and the organization structure utilized by management in achieving results. It is well to remember, however, that a chart is but a map and is necessarily as deficient in presenting the personalities, intellectual strength and initiative of an organization as a map is in making real a living landscape.

Some firms dispense with the use of charts as a means of presenting a picture of the organization structure. They are regarded as unnecessary, or it is felt charts fail to reflect the true value of individuals, place too much emphasis upon titles or positions, and perhaps need to be revised too frequently. An objection to charts has been that they tend to restrict mental activity and interest too rigidly within established boundaries. If so, by checking stimulating criticism and suggestion, they may beget a complacency that brings mediocrity of achievement. This condition is noticeable in some large concerns. While definite duties are, of course, essential, these must be combined with the possibility of breadth of thought and interest which brings understanding and mutual helpfulness, and in this way makes cooperation possible and effective. Every ambitious man wants an outlet for his energies and intelligence. If he is unduly restricted in expressing himself, he will seek his chance elsewhere, thus depriving the firm of the very man it is seeking to discover, develop, and retain.

Chart positions do not necessarily indicate the worth of the individual, nor the nature or value of his activities. The assistant to the president or general manager cannot function along definitely prescribed lines, nor be restricted by charted boundaries. His value lies in a wide perspective. The prestige which such a position carries among subordinate executives enables him to perform staff work, initiate new activities, eliminate friction, and provide his chief with an intimate understanding of factory life behind the scenes. Leadership, enthusiasm, and other talents possessed

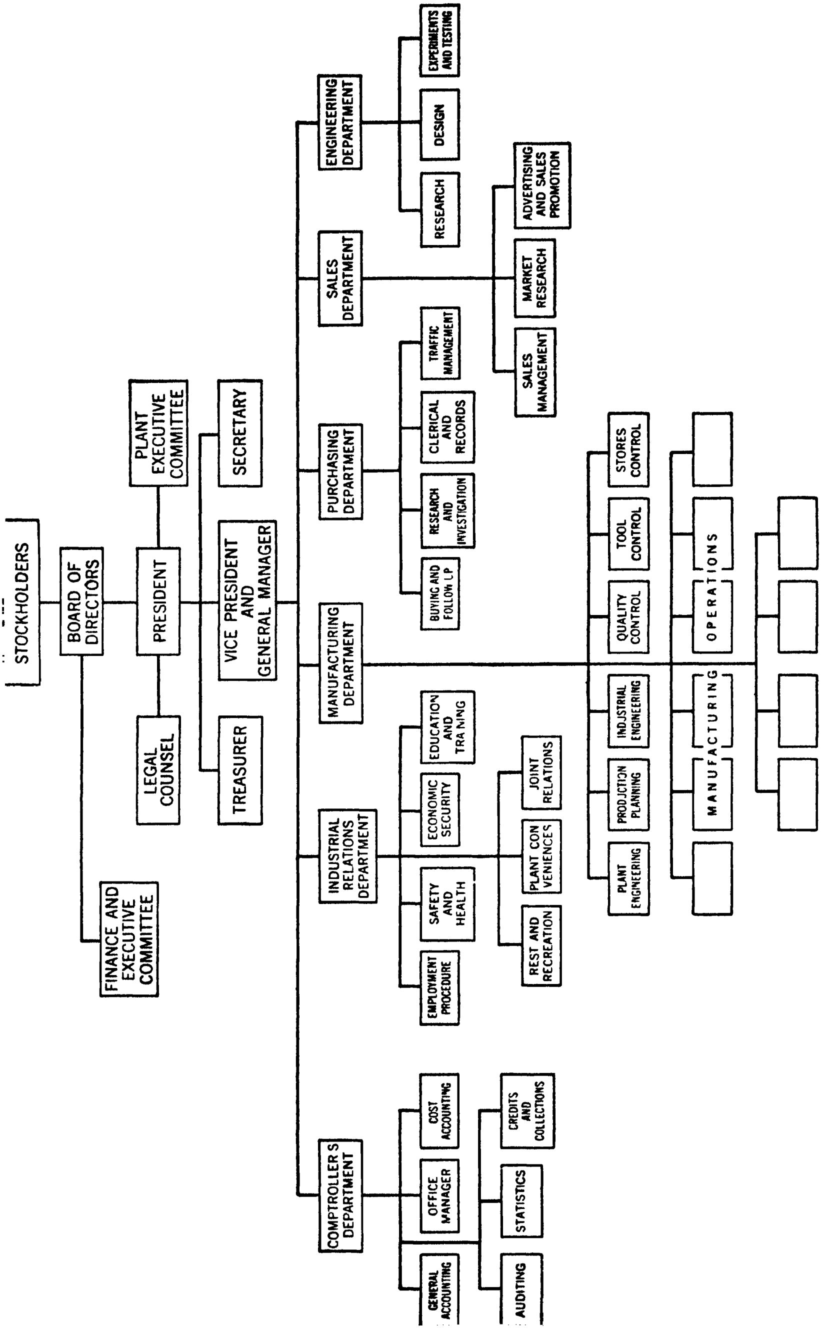


Figure 14 Organization Chart of a Representative Manufacturing Company

by individuals, will not be obvious upon a chart, and the wisdom of choice of personnel may be questioned and cause dissatisfaction.

As changes in the staff occur, or as the firm grows or adjusts itself to new demands made upon it, readjustments must take place in the assignment of work to be done. The chart should, of course, be changed in accordance with the change in assignment of duties. It should be an exact picture of the existing company organization.

Charts probably prove of most value in indicating the framework of the organization, its functional development, and in serving as a guide in its logical growth. Some examples illustrate their successful use.

Chart of a Representative Manufacturing Company.—A chart of a representative manufacturing company is shown in Figure 14. In a small company the same functions and activities would be present, but there would be less specialization. In that case industrial relations and purchasing might be made divisions of the manufacturing department. Similarly, the offices of secretary and treasurer could be combined, or those of treasurer and comptroller, and others likewise. Conversely, as companies grow larger a greater degree of specialization would result, with lesser departments becoming more important, and meriting a separate and perhaps higher place in the organization structure. Particularly important major departments might be administered by officials with the rank of vice president.

This chart provides a picture of the organization structure, indicates what activities are carried on, and their place in the general scheme. Lines of authority and responsibility are clearly evident. Tendencies for duplication of effort, for overlapping, for omissions or lack of balance in activities become more apparent by being presented in this form. Detail charts of subdepartments and divisions would likewise be helpful to the president or vice president in considering the work of each and planning for the future.

Organization Chart of General Motors Corporation.—Figure 15a shows the organization of the General Motors Corporation. The corporation is governed by the stockholders through the board of directors and its chairman, who is the chief executive officer. In explanation of this organization structure the company in a message to its stockholders wrote as follows:

An analysis of the problems that confront industrial management will demonstrate that there are really two groups of such problems:—first, questions involving policy, both general in character and as affecting the operating technique: and second. questions involving administration of

policy when once developed and established. While these two groups are, of necessity, closely related, they become more and more separated as the business increases in size. In an institution as large in the magnitude of its operations and as diversified in the scope of its activities as is General Motors, they reach the point where they are sufficiently separated as to be dealt with, to an important degree, independently.

While the success of any business will always depend upon efficient and intelligent administration, it is perfectly clear, in looking back over the past few years, as well as in attempting to discount the general trend as to the future, that the policy phase of management is becoming of greater and greater importance. . . .

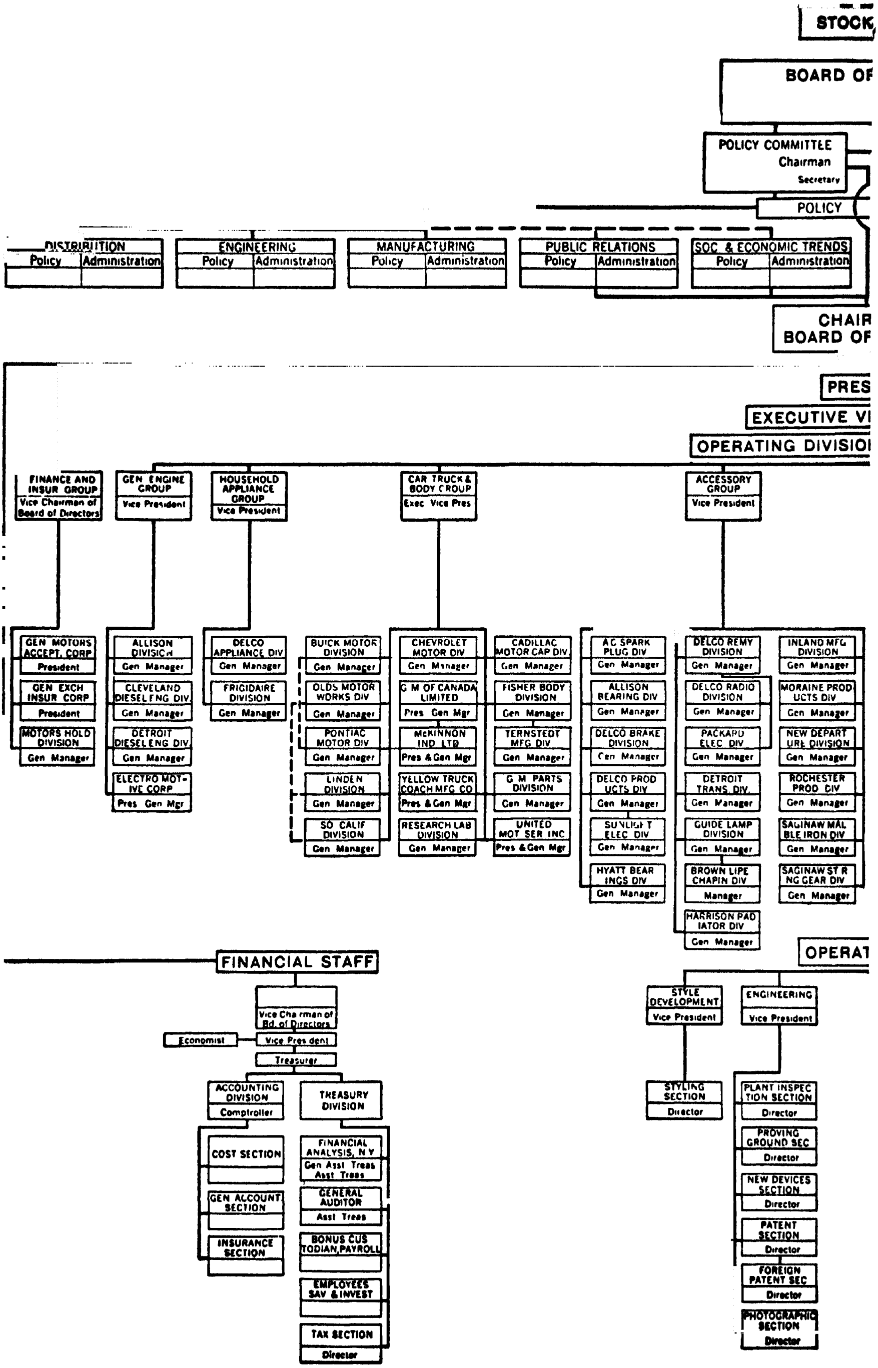
Experience has likewise demonstrated that the day to day problems that confront the corporation's operating executives are so absorbing in their demands of time, that too little opportunity is afforded for the necessary consideration of the broader aspects of the business and the development of a better operating technique which require much study and research. The marvelous contribution that research has made to the progress of industry and the advancement of the standard of living, is universally accepted. It is not so generally recognized, however, that research may be equally well applied—and it is important that it should be applied—to all functional activities of business. . . .

The present plan of organization definitely separates policy from administration, and at the same time provides the essential coordination between the two. It also provides for a greater decentralization of the responsibility for the corporation's general administration, in order that more executive consideration may be devoted to the policy phase of the business.

The chairman of the board is the chief executive officer. The policy committee of the board deals with both financial and operating problems from the standpoint of general policy, and also will have the responsibility of promoting new policies involving all the corporation's functional activities. The administration committee of the board has charge of the administration of all the corporation's divisional and subsidiary operations, excepting those of a strictly financial character. It, in collaboration with the policy committee, participates in the development of the policy phase of the business. . . .

To sum up: the advantages are a greater decentralization of responsibility; the more definite segregation between policy and administration, permitting more executive attention to the policy phase; and the provision for transition of executive personnel through the corporation's service as experience grows and ability is demonstrated.

It will be noted that production operations are grouped by kind, and further divided into divisions, which are in effect separate businesses of distinct classification. Each of these operating units is self-contained, with an organization and chief executive of its own. It buys and sells to



STOCK
BOARD OF
POLICY COMMITTEE
Chairman
Secretary
POLICY
DISTRIBUTION
Policy
Administration
ENGINEERING
Policy
Administration
MANUFACTURING
Policy
Administration
PUBLIC RELATIONS
Policy
Administration
SOC. & ECONOMIC TRENDS
Policy
Administration
CHAIR
BOARD OF
PRES
EXECUTIVE VI
OPERATING DIVISIO
FINANCE AND INSUR. GROUP
Vice Chairman of Board of Directors
GEN. ENGINE GROUP
Vice President
HOUSEHOLD APPLIANCE GROUP
Vice President
CAR TRUCK & BODY GROUP
Exec. Vice Pres.
ACCESSORY GROUP
Vice President
GEN. MOTORS ACCEPT. CORP.
President
GEN. EXCH. INSUR. CORP.
President
MOTORS HOLD. DIVISION
Gen. Manager
ALLISON DIVISION
Gen. Manager
CLEVELAND DIESEL ENG. DIV.
Gen. Manager
DETROIT DIESEL ENG. DIV.
Gen. Manager
ELECTRO MOTIVE CORP.
Pres. Gen. Mgr.
DELCO APPLIANCE DIV.
Gen. Manager
FRIGIDAIRE DIVISION
Gen. Manager
BUICK MOTOR DIVISION
Gen. Manager
OLDS MOTOR WORKS DIV.
Gen. Manager
PONTIAC MOTOR DIV.
Gen. Manager
LINDEN DIVISION
Gen. Manager
SO. CALIF. DIVISION
Gen. Manager
CHEVROLET MOTOR DIV.
Gen. Manager
G. M. OF CANADA LIMITED
Pres. Gen. Mgr.
McKINNON IND. LTD.
Pres. & Gen. Mgr.
YELLOW TRUCK COACH MFG. CO.
Pres. & Gen. Mgr.
RESEARCH LAB. DIVISION
Gen. Manager
CADILLAC MOTOR CAR DIV.
Gen. Manager
FISHER BODY DIVISION
Gen. Manager
TERNSTEDT MFG. DIV.
Gen. Manager
G. M. PARTS DIVISION
Gen. Manager
UNITED MOT. SER. INC.
Pres. & Gen. Mgr.
A C SPARK PLUG DIV.
Gen. Manager
ALLISON BEARING DIV.
Gen. Manager
DELCO BRAKE DIVISION
Gen. Manager
DELCO PRODUCTS DIV.
Gen. Manager
SUNLIGHT ELEC. DIV.
Gen. Manager
HYATT BEARINGS DIV.
Gen. Manager
DELCO REMY DIVISION
Gen. Manager
DELCO RADIO DIVISION
Gen. Manager
PACKARD ELEC. DIV.
Gen. Manager
DETROIT TRANS. DIV.
Gen. Manager
GUIDE LAMP DIVISION
Gen. Manager
BROWN LIPE CHAPIN DIV.
Manager
HARRISON RADIATOR DIV.
Gen. Manager
INLAND MFG. DIVISION
Gen. Manager
MORAINE PRODUCTS DIV.
Gen. Manager
NEW DEPARTURE DIVISION
Gen. Manager
ROCHESTER PROD. DIV.
Gen. Manager
SAGINAW MALLEABLE IRON DIV.
Gen. Manager
SAGINAW STEERING GEAR DIV.
Gen. Manager
FINANCIAL STAFF
Vice Chairman of Bd. of Directors
Economist
Vice President
Treasurer
ACCOUNTING DIVISION
Comptroller
TREASURY DIVISION
COST SECTION
GEN. ACCOUNT. SECTION
INSURANCE SECTION
FINANCIAL ANALYSIS, N.Y.
Gen. Asst. Treas.
Asst. Treas.
GENERAL AUDITOR
Asst. Treas.
BONUS CUSTODIAN, PAYROLL
EMPLOYEES SAV. & INVEST.
TAX SECTION
Director
OPERAT
STYLE DEVELOPMENT
Vice President
STYLING SECTION
Director
ENGINEERING
Vice President
PLANT INSPECTION SECTION
Director
PROVING GROUND SEC.
Director
NEW DEVICES SECTION
Director
PATENT SECTION
Director
FOREIGN PATENT SEC.
Director
PHOTOGRAPHIC SECTION
Director

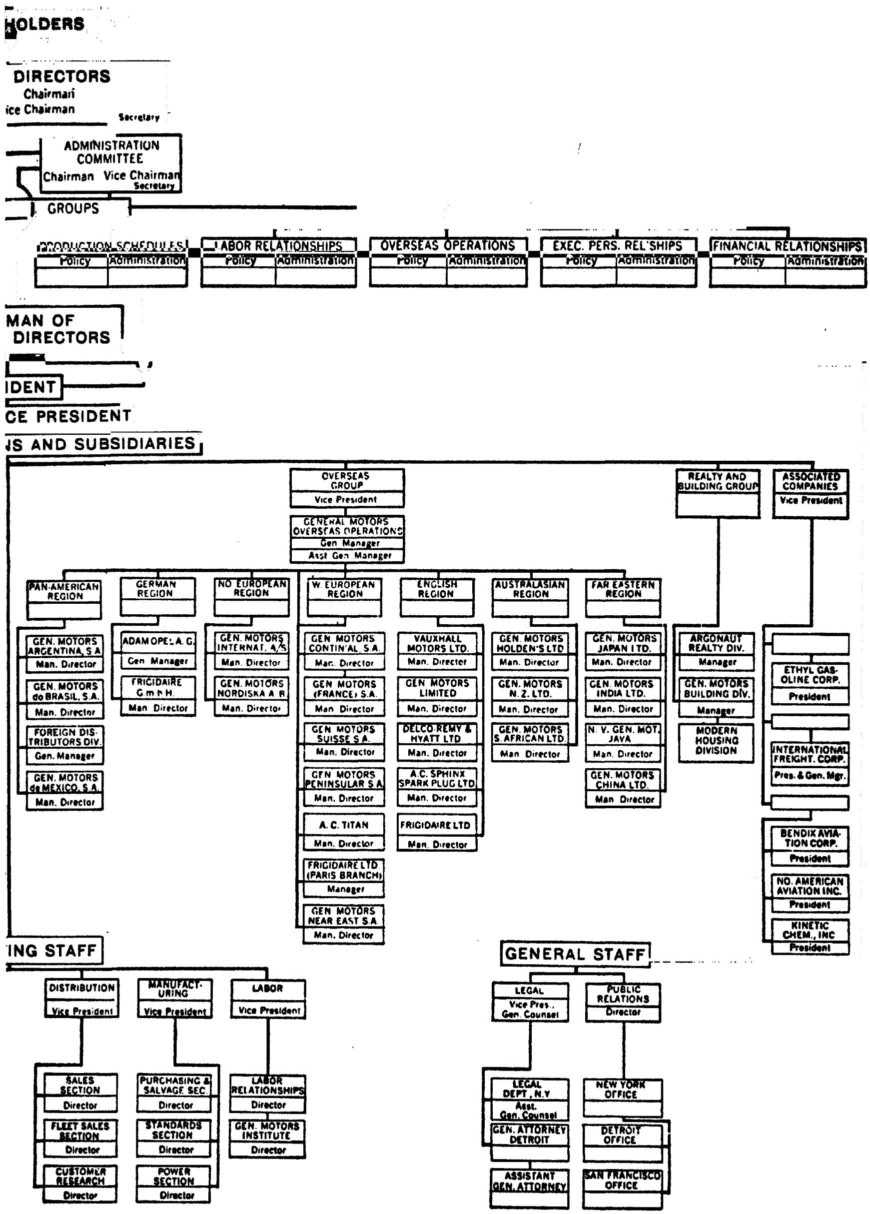


Figure 15a. General Organization Chart of General Motors Corporation

other divisions and to outside firms on a competitive basis, and is judged as to results by certain established standards and comparison with similar competitive enterprises. It has the advantages of staff service through its relationship with the parent organization, and the other advantages which accrue to a large company. These would include prestige, financial strength, purchasing advantages, benefits from research, and talents of a high order in the upper ranks of executives.

The General Motors organization combines the advantages of a decentralized system, with its incentive to individual initiative, and those of a closely knit central organization. A consistent effort is made to individualize divisions and departments so as to develop their initiative to the fullest extent. At the same time composite knowledge and experience of the entire organization are pooled in such a way as to make them available and of value to everyone concerned.

Organization Chart of a Corn Products Plant.—Figure 15b is an organization chart of a corn products company. It pictures the organization as a whole, indicates the various departments, and the lines of authority and responsibility. The industrial engineer investigates and reports to the general manager with respect to possible operating and management economies. In putting new procedures into effect, however, he actually works with or comes under the direction of the general superintendent. The assistant superintendent, the chief engineer, and the chief chemist, although shown as line men, also serve to a considerable extent as staff advisers. There is a notable lack of coordinating committees, and this is typical of many continuous process industries, such as cement plants, flour mills, brickyards, and the like. In such plants manufacture is controlled largely by machinery; the problems of routing, shop transportation, production control, and of workmen operating individual machines are conspicuously absent.

The task of the operating management in such an organization is to a great extent a technical one—maintaining and tending continuous process machinery and providing a check on its proper functioning. In the case of corn products, corn as a raw material enters at one point, and at remote points there emerge starches, syrup, sugar, oil, feeds, and various by-products. In the manufacturing operations little skilled labor is required. A staff of chemists serves all the process departments and thus controls quality. The installation and maintenance of equipment are also carried on functionally by the master mechanic and his staff.

Within each department indicated on the chart there will be a departmental organization, usually of a line character. For instance, the several departments under the chief engineer will each have a foreman, an assist-

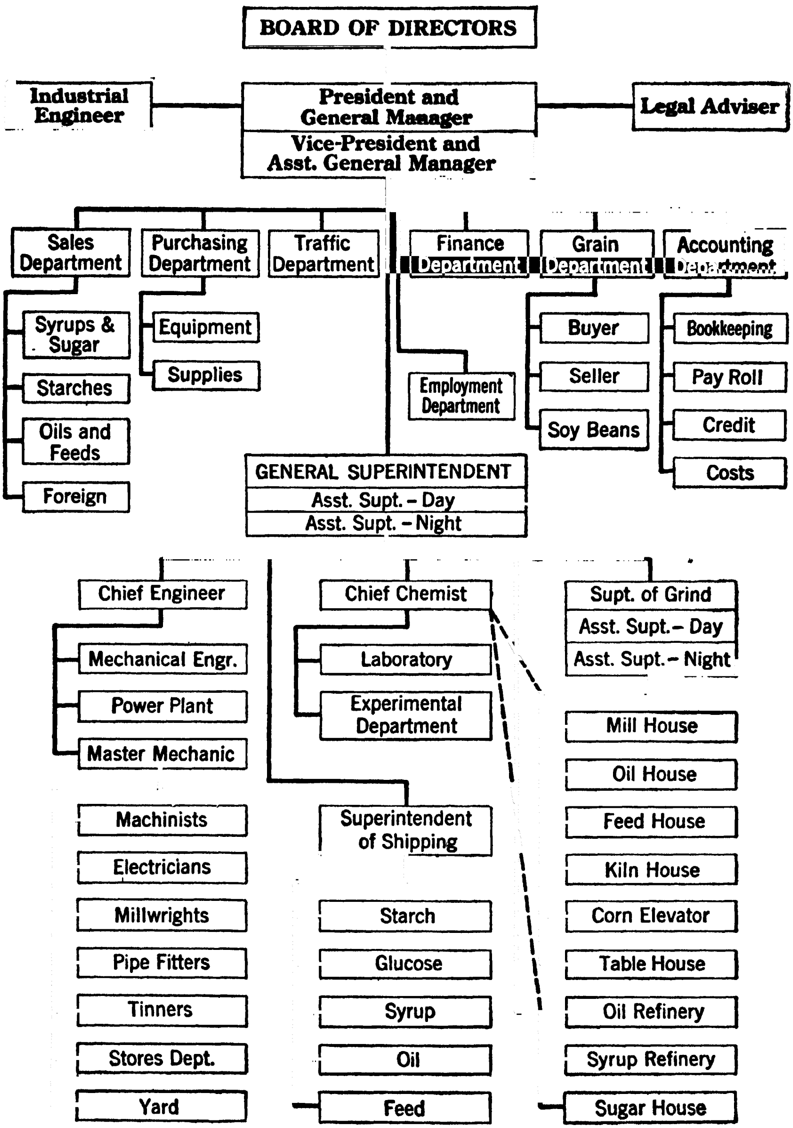


Figure 15b. Organization Chart of Corn Products Plant

ant foreman, and a staff of workmen. The accounting department will have bookkeepers, clerks, and stenographers.

Chart of Organization of a Furniture Plant.—Figure 16 shows the organization of a furniture manufacturing enterprise employing from 150 to 175 workers. This type of organization has been proved most profitable and successful in actual operation.

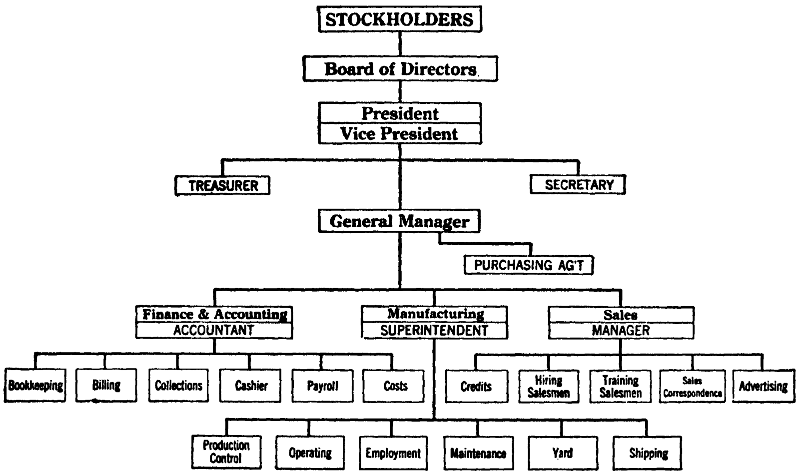


Figure 16. An Effective Organization for a Small Company

Charts of Organization of the American Rolling Mill Company.—The chart in Figure 17 shows in outline the organization structure of the corporation and the plan of administration and management. It will be noted that business and production activities are carried on in several localities. The main offices of the company are located at Middletown, Ohio, one of the points of major operation activity. The president, senior vice president, and secretary of the company are also members of the board of directors. Executive control is exercised through the medium of the president and senior vice president, and the chief management group as shown on this chart.

The chart in Figure 18 pictures the management of the Middletown Division of the corporation. General corporation policies, plans, and procedures are carried into effect for this division through the medium of the works management group. Executive authority and responsibility center in the works manager, assistant works manager, general superintendent, and assistant general superintendent. In large organizations it is often the practice not only to have general organization charts such

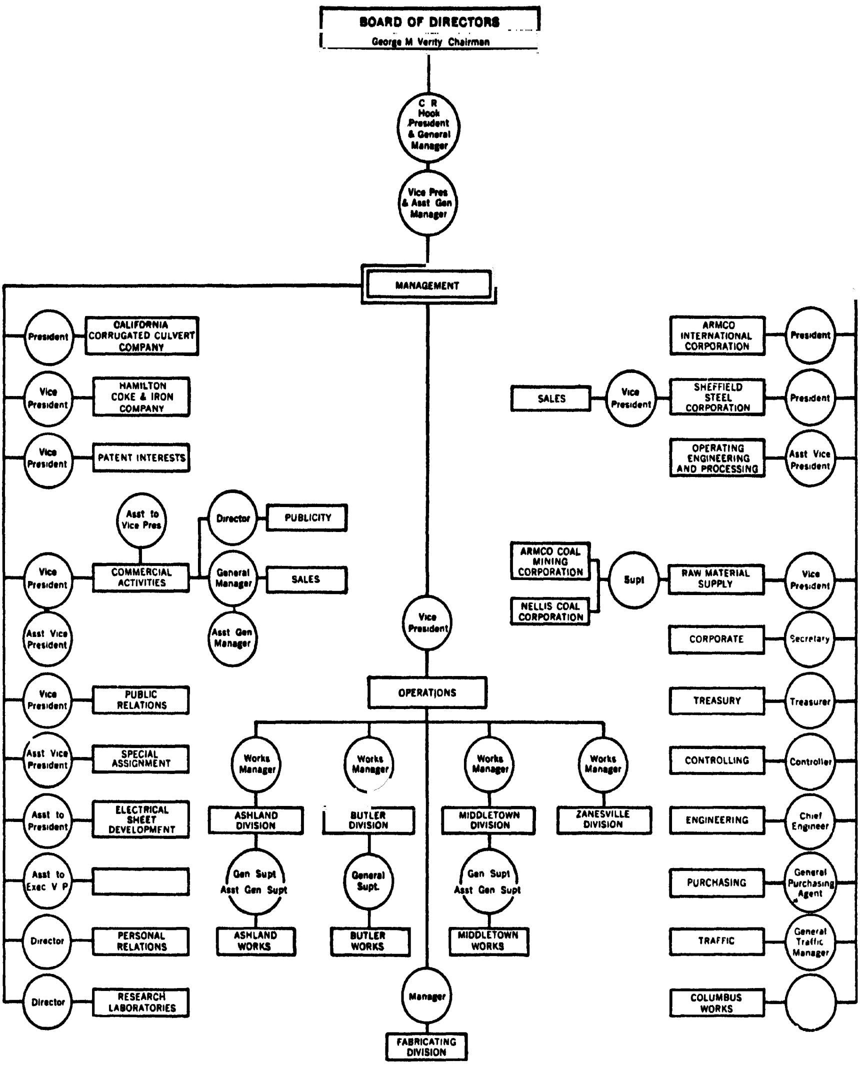


Figure 17. General Organization Chart of the American Rolling Mill Company

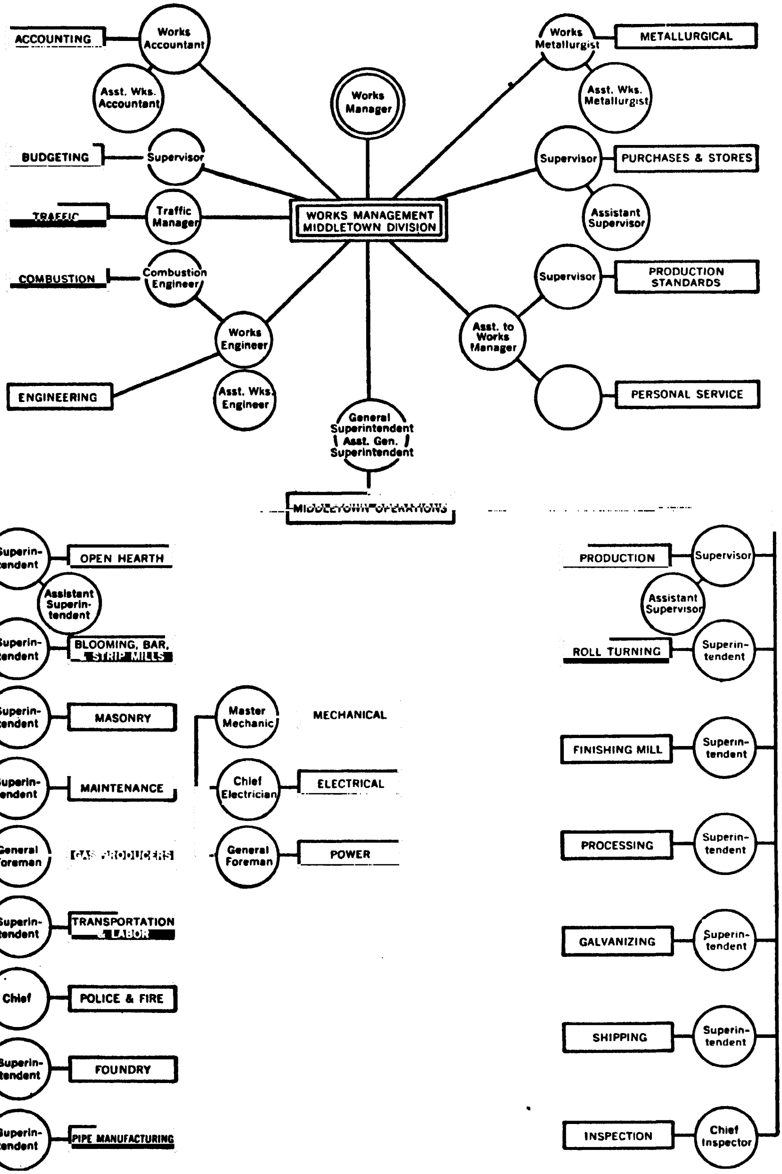


Figure 18. Organization Chart of the Middletown Division of the American Rolling Mill Company

as the two here shown, but to supplement these with charts of similar design for each phase of activity which show the position and nature of the work performed by each and every employee. These are helpful to the executives immediately concerned, as well as in accounting, cost control, and budgeting. Detail changes in personnel or readjustment and expansion of work do not necessitate changes in the general charts. These latter charts provide major executives and the board of directors with a picture of the general organization structure, corporation activities, and of the channels through which management control is exercised.

A foremen's forum meets once a month for the exchange of opinions, the charting of operations, the study of company policies, and a thorough understanding of the human element in business as it should be known by those who represent the management on the job.

Charts necessarily fail in conveying an impression of the relationship which a company maintains with the public, with its stockholders, and employees. In all these respects this corporation has a most enviable record. The corporation's policy is to cooperate with all worthwhile community organizations and activities. Works managers have authority to act for the company in such matters, and both executives and employees are urged to support and to take an active part in community affairs. An industrial relations program has been in effect since shortly after the company was organized in 1900. That it has been effective is evidenced by the fact that in its entire history the company has never lost a pound of production, nor an employee a dollar of wages because of labor trouble.

In 1904 employee representation had its beginning with this company. One employee representative is elected to approximately 50 employees. Departmental committees elect their own chairmen, and these chairmen in turn select a general chairman, vice chairman, and secretary. The committees have no administrative, legislative, or executive functions. At least once each month all employee representatives meet with the plant management and the supervisory group for the purpose of bringing about a better understanding of company policies, and for the exchange of information that will be mutually helpful. An employee with a grievance may take the matter up with the department superintendent either in person or through an employee representative of his department. If a satisfactory agreement is not reached it may be appealed by successive steps to the president of the company, and to an impartial arbitration board, although this latter step has never been found necessary.[1]

[1] "Armco Personnel Relations," by Hugh W. Wright, *Factory Management and Maintenance,* Vol. 95, No. 5, Supplement.

Chart of Company Manufacturing Automotive and Other Machinery Products.—This company operating a large plant very successfully has a simplified organization scheme with but three main divisions of its operating activities, each administered by a vice president. (See Figure 19.) The function of the "vice president in charge of product" is to advise the president and all departments of the company concerning matters which affect the particular group of products for which he is responsible, and their distribution. The dotted line indicates the direct relationship with operating departments. It is anticipated that future growth of the business will require the appointment of additional executives with like responsibility for other products. The product study department is responsible for relations with manufacturers of products used with this company's equipment, and for cooperation with them to the end that sales are increased to a satisfactory point. Staff service is utilized by various executives as necessary. Subordinate departments are organized by functions and are of the line type.

Trends in Organization.—A noticeable trend in recent years has been for big organizations to decentralize activities, including both operations and management. This is particularly to be noted in connection with the General Motors Corporation as presented earlier in this chapter. Another company in the electrical equipment field has divided its business into twenty-two divisions, each separately organized and managed. The determination of company policy is centralized. Cooperation and coordination with respect to finance, purchasing, advertising, research, and staff service are likewise provided for.

Large companies have found that functional organization sometimes tends to increase costs out of proportion to the service rendered. This comes about because of ambition on the part of the executive in charge to expand and elaborate his service, and because the cost can usually be prorated as an overhead charge among the departments utilizing the service. In several large companies production department costs were found to be out of line because certain functional services rendered by other departments were being charged for out of proportion to their value. When costs are not subject to control by the executives immediately concerned, or there are not effective ways of evaluating results in terms of cost, weakness ensues. A medium-sized organization engaged in the production and distribution of one or a few products has certain advantages. There are likely to be similar, competitive organizations with which it may compare operating costs and profits. Its size will permit a capable, energetic executive to exercise command and be a potent influence in all departments. Thus big corporations are seeking

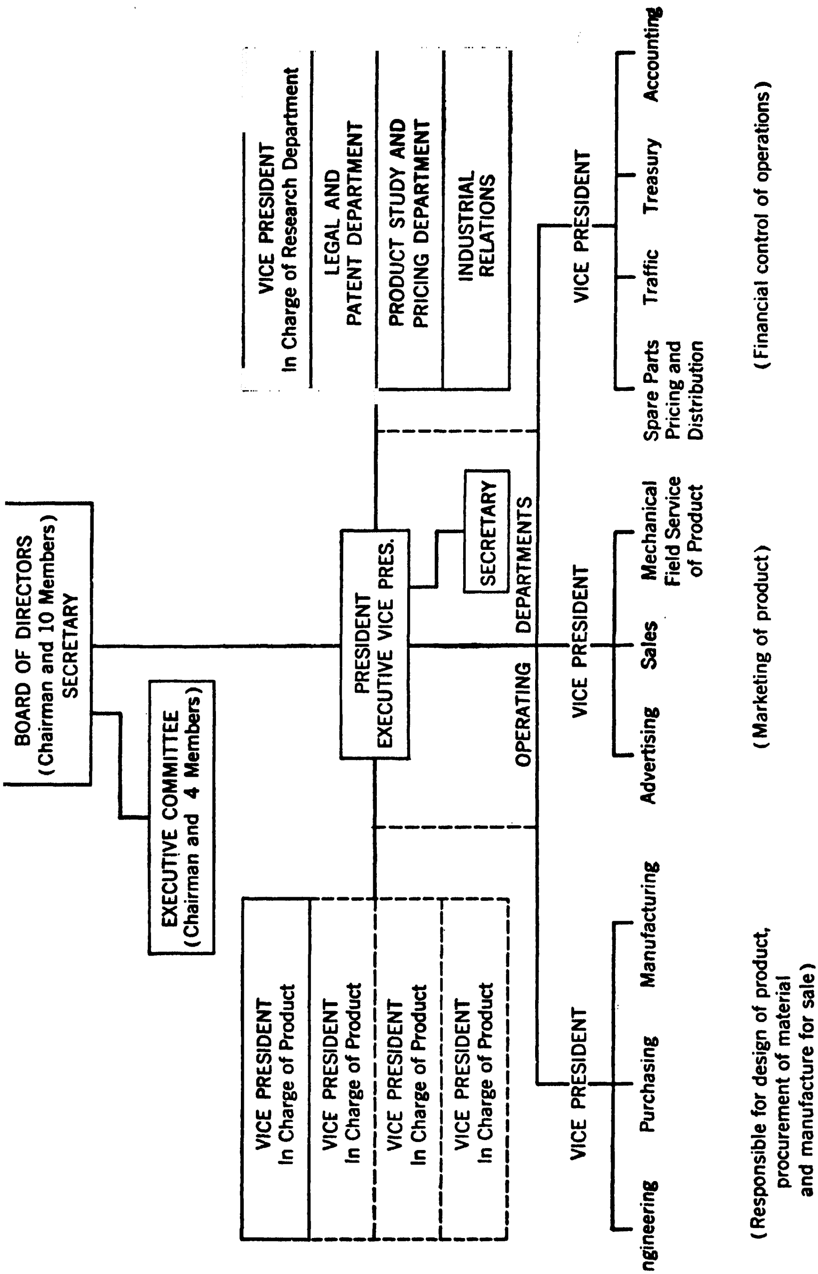


Figure 19. Chart of Company Manufacturing Automotive and Other Machinery Products

to regain the advantages of the smaller enterprise without sacrificing the benefits which may accrue from a strong parent organization.

Public relations and labor relations are two important factors influencing smaller plants. The bond between a plant and the community in which it is located is important. With a controlling management in charge motivated by a general policy favoring participation in plans for community well-being and progress, the evils of absentee management are eliminated. Opportunity is offered for ranking executives to be in touch with working conditions and to have first-hand contacts with the personnel. Such a relationship offers much opportunity for eliminating or minimizing labor difficulties.

Benefits of Modern Business Organization.—The benefits which may accrue from success in organization work are expressed by Walter P. Chrysler, as follows:

> In the development of the great modern business corporations as servants of mankind, men have devised a creative force that transcends themselves. None of these corporations are perfect as yet, of course; but . . . what other time in history can show anything to compare with these teams of men, in capacity to enrich mankind, in capacity to extend human powers in almost any direction we may wish to go.
>
> Nourished by such a mind as that of Kettering of General Motors or Fred Zeder of the Chrysler Corporation, a great corporation's departmentalized intelligence becomes still greater; but to support a Kettering there must be other kinds of minds, those of production men, of merchants, of mechanics, of advertising men and countless others. When all these minds, through organization, are made to function as a single intelligence, each member of which is a special, gifted part, then you can expect to produce magic. Nowhere in the world is there a people with wealth so widespread as in America; nowhere is there a people who have so much. It seems to me quite obvious that we do not owe this difference to a few outstanding men; we owe it to a scheme of working whereby a lot of varied intelligences in a great business organization pool their most effective parts.[2]

[2] From a series of articles "Life of an American Workman," by Walter P. Chrysler, in *The Saturday Evening Post.*

CHAPTER 8

SELECTING A LOCATION

Need for Care in Selecting a Site.—When a location for a plant is once selected it is assumed that the industry will continue in this spot for a considerable time. Moving is difficult and entails considerable costs. Therefore it behooves the management of a company to consider the problem of location carefully and not arrive at a decision until all factors are given their proper weight. In general it may be said that the best location for a manufacturing plant is where the combined cost of production and distribution of its product is the lowest. But the solution of this problem is not one that can be arrived at easily. In the case of a small company, the determination is all too frequently made on the basis of the owner's preference of a home community or the availability of a plant site. Later on, this location may prove a decided handicap to the success of the firm. A large company may spend months or even years in analyzing various data and compiling cost figures before deciding where to move the main plant or establish a branch. With the growth and shifting of population, changing transportation facilities, the development of new materials and processes, and the establishing of new power areas, the question of the most desirable site has become increasingly prominent for the maintenance of profitable operations.

Concentration in Certain Centers.—An industrial map of the country records a past tendency for factories in a given industry to locate in certain centers or areas. Examples are the milling industry at Rochester and Minneapolis, the automobile industry at Detroit, textiles in New England, furniture at Grand Rapids, agricultural implements at Chicago, the garment industry in New York City, the rubber industry at Akron, and steel manufacturing and consuming enterprises first at Philadelphia and later at Pittsburgh. Time brings changes, however, and natural or other advantages once enjoyed may be diminished or cease to exist, as evidenced by the recession of forests from the locality of Grand Rapids, the decentralization of the rubber industry, and the new centers of the steel industry at the southern end of Lake Michigan and Birmingham, Alabama, in response to developing markets.

Until recent years the concentration of an industry, whatever the cause, tended to create a favoring environment. Some of these changes

were of a nature to benefit manufacturers generally; others, favoring the particular industry concerned. Industrial concentrations brought about the establishment of subsidiary and auxiliary factories which provided machinery and tools, special parts, accessories, and supplies. Specialization and segregation of accessory manufacturing operations in independent plants often proved profitable to all concerned. Labor congregated where individual plant shutdowns least affected continuity of employment. Purchasing conditions were bettered and transportation facilities, mainly railroads, were expanded and the service improved. In addition, financing became easier, public opinion more favorable, advertising prestige greater, and technical advancement more rapid. The gain in such external economies accounts for the past concentration of many industries. The tire industry at Akron, largely through such concentration, built up a favorable environment for itself without possessing many natural advantages. The agricultural implement industry, when it moved to Chicago from the East in 1845, successfully undertook to create an environment favorable to industrial progress, in a comparatively rural community. Nearness to market and raw material sources warranted such an effort. at a time when it was without precedent.

THE GEOGRAPHICAL LOCATION

Points to Consider.—The factors influencing the choice of a geographical location may be divided into groups of primary and secondary importance.

Primary Factors	Secondary Factors
Market	Legislation
Raw Materials	Climate
Labor	Financial aids
Transportation	Banking facilities
Power and fuel	Water supply

The importance of each of these factors will vary with different industries and with each analysis made. Sometimes one essential need may govern the choice for a particular company.

Migration and Decentralization—Technical Progress.—Industry is always on the move and readjusting itself to meet existing and foreseen conditions. Migration, centralization, and decentralization trends are brought about by changes which occur in connection with technical progress as well as with the location factors previously listed.

Technical progress in the steel industry in the use of local coal for coking operations and the greater use of scrap in making steel are

decentralizing forces. The use of bark in leather tanning operations formerly required the handling and storage of large piles of this material. The use of an extract obviates this need and permits the operations to be carried on in quite different localities. A new process has made it possible to produce kraft paper and certain kinds of pulp from southern pine which can be grown on a crop basis. The consequence has been a big shift in paper production from the northern to the southern states, and the investment of many millions of dollars in new paper mills. In the entire industry smaller plants are now just as efficient or more so than larger plants. The Ford Motor Company now operates fourteen small plants within a radius of fifty miles of Detroit. Many of them do not have railway connections. These plants produce starters, generators, lamps, gauges, drills, and other parts.

Community Assistance in Plant Location.—Chambers of Commerce and other community groups often interest themselves in prospective new industries. In a past era unwise competition between communities resulted in offers of free sites, bonuses, stock subscriptions, and exemption from taxes as inducements. Where one plant was properly located in this way, scores were located improperly and failed to survive. Many cities have industrial graveyards due to this cause, and local investors much worthless stock. Temporary advantages cannot compensate for uneconomic production and distribution over a long period of years. The long-time effect of each influencing factor must be carefully weighed in relation to others, and the location must be chosen which provides the sum total of advantages. When an analysis discloses that several communities offer about equal advantages, then inducements by one or more of them may logically influence a choice. A manufacturing company adds purchasing power to a population group through its payrolls and local purchases, and contributes directly and indirectly in taxes. More people may come to reside in the community. These are gains which business men appreciate, and which may warrant reasonable community cooperation and aid.

The Market.—Perhaps the market is the one factor which most frequently influences the choice of an industrial location. Goods are manufactured to sell and their production is either in response to an existing demand or with the idea of creating a demand for them. The rise of industry on the Pacific Coast was in response to an increasing market. Many industries are essentially local in character, such as laundries, ice-cream factories, bakeries, planing mills, common furniture factories, foundries, artificial ice plants, brickyards, printing establishments, and machine shops. In connection with these the possibility of

rendering unusual service or offering low prices, because of favorable production conditions, will often greatly increase the market range. It is usually cheaper to produce the more ordinary heavy and bulky products of small value near the market, other conditions being equal. On the other hand, there are many commodities which can be produced independent of the adjacent market. As examples may be mentioned: goods of high value and small bulk, such as jewelry; goods in which style is a large factor, as in the case of clothing and high-grade furniture; technical or chemical goods, and specialties generally.

Management talent is now relatively plentiful, and this fact coupled with the technical efficiency of smaller manufacturing units promises a greater decentralization of establishments designed to serve local or regional areas, especially consumer goods plants.

Determining Extent of the Market.—A market analysis covering both present and future possible markets is an essential part of any program leading to the establishment of a plant. A manufacturer will desire to know: (1) the extent of local demand, (2) other markets, (3) the prospective future demand, and (4) existing and probable future competition. It may be unwise to locate with reference merely to a present sales territory, if it involves ignoring future market trends which seem to suggest growth in another direction. Market analyses merit the attention of experienced surveyors, skilled in finding and assembling pertinent and significant facts, discarding irrelevant data, and interpreting accurately the real meaning of the figures presented. A given plant may not expect to supply the entire market, and the problem then is to determine what share of the business it will command, considering its product, prestige, and the price at which it can make sales.

Shifting Markets.—The shifting of markets in the United States has caused a continual readjustment of production centers. Starting in the East with local production for local consumption almost entirely, there gradually emerged strategic production centers for many major industries, from which national distribution was effected. With the steady westward movement of population, industry has moved westward and we now have the center of many industries in the Mississippi Valley. Natural advantages for low cost steel production and distribution at the southern end of Lake Michigan are responsible for the rapid development of the industry there. The cost of production is less and the cost of shipment to the great middle-western market is much less than from Pittsburgh. The recent addition to the plants in the Birmingham area is in part due to market influence, and in part to raw materials.

High freight rates increase the tendency of industry to follow the market. Many industries in recent years have established plants on the Pacific Coast, notably in the Los Angeles region, to save freight on shipments from the East. Regional production centers are tending to develop, and a company seeking national distribution may have a number of plants at strategic regional locations, rather than attempt distribution from one point. Decentralization of production by a large manufacturer will result in branch plants centrally owned and controlled. Shifting markets, however, have also brought a marked increase in the number of small competitive plants. A good example of the establishment of branch factories is the large number of regional assembly plants operated by the principal automobile companies. Other examples of this kind of operation are bakery goods, tin cans for fruit and vegetable packing, furniture, cement, meat packing, and industrial gases which are shipped in heavy steel cylinders.

Sources of Raw Materials.—The sources of raw materials should be studied with respect to: (1) quantity and quality available, (2) proximity, (3) transportation costs, (4) extent of competitive or monopoly market, and (5) the possibility of future use of substitutes. The extent and character of natural commodities, such as timber, mineral deposits, clay, or supplies originating from agricultural operations, may be quite accurately determined. Where the finished product of another industry is utilized, or a by-product or waste, the continuity of an adequate supply will have to be analyzed along different lines. Imported products may need to be considered. Many raw materials may be incorporated in a finished product, but usually in each industry a limited few only are of prime importance in affecting location.

Effect of Material Sources on Location.—The source of natural deposits or supplies will arbitrarily locate certain industries, such as mining, fishing, lumbering, and petroleum production. Nearness to the source is important in the case of heavy and bulky materials of relatively small value, or when the raw material loses considerable weight or bulk during process of manufacture; also when transportation facilities are inadequate or costly. Ore is preferably smelted near the mines. Sawmills and paper mills using wood pulp follow the forests, utilizing streams to carry the logs to them. Starch factories locate in the corn belt and at corn market centers. With raw products that are perishable, such as canning supplies, sugar cane and beets, and raw dairy products, storage or long shipments are impracticable. In the case of milk product plants producing cheese or evaporated milk a location somewhat distant from population centers is desirable, in order that consumer demand may not

affect the continuity of supply or regulate raw material costs. Thus, in general, there is a tendency to perform the primary manufacturing operations in the vicinity of the raw material supply. Price fluctuations will be minimized by purchasing in a market handling a relatively large volume of the product.

Less dependent upon nearness to raw materials are those manufacturing operations following the primary ones, those which involve the application of more labor and the use of special machinery and a small amount of power. These include many finishing processes which are affected by style changes and customer demands, also products in which the cost of raw material is small, as compared with the total cost or selling price. Many products which are marketed nationally are also independent of proximity to raw materials. The cost of shipping raw materials for a given product may be much less than that of shipping the product in a finished state, and consequently may suggest local manufacturing. Common furniture and paper boxes are examples.

Labor.—The expansion of industry, the relative increases in our industrial population, the rapidly increasing introduction of mechanical equipment and automatic machines, have steadily tended to lessen the importance of labor as an essential element in industrial location. Generally speaking, unskilled or semi-skilled labor can be developed locally, or it will follow the industry. Highly skilled and specialized branches of craftsmanship may call for a labor supply which is not obtainable locally. Usually, however, no great difficulties are encountered in transplanting a necessary number of such workmen.

The efficiency of the human element influences production costs, no matter how scientifically laid out and equipped the plant may be. It should be studied carefully by individuals possessed of a thorough knowledge and experience in the field of personnel relations, to the end that an adequate, satisfied, and contented operating staff will be available. Intelligence, skill, and thrifty habits are characteristics to be looked for.

Effects of Labor Strife.—The best labor market is, of course, found in the cities, but in recent years there has been a noticeable movement of industry from the cities to the smaller towns. To a large extent this is a result of difficulties in dealing with unions and labor leaders in large industrial centers, the rules and restrictions to production consequent upon union regulations, and the increased costs due to high wages and low production schedules. Labor turnover rates of various cities tell the story of industrial unrest. In the vicinity of certain cities, industrial suburbs have sprung up in which amicable relations between employers

and employees have been promoted, with the resulting combination of a favorable labor situation and the advantages of a city location.

There are a number of smaller industrial towns about the country in which labor populations have grown with the industries located there, and in which a common bond of loyalty and cooperation has developed. In these towns the greater dependence of labor upon particular jobs minimizes agitation, unrest, and labor turnover.

Where the labor demands of a plant will interlock with the requirements of factories already located, smaller cities often prove very attractive. In an Illinois town, for example, the demand for women workers in a cotton yarn and hosiery mill fits in very nicely with the need of a furniture factory for men workers. Not only are the manufacturers benefited, but the purchasing power of families is increased with resultant gain to business and the community generally. During a period of two decades employees have made a decided advance in educational standards, cultural growth, and economic well-being.

Labor strife in recent years has developed between rival unions, between labor leaders, and because of the influence of politics. Control of labor groups by unscrupulous leaders is another evil. Communities differ greatly in their freedom from troubles of this kind. It is important to know the past record and present attitude of local public officials in dealing with unlawful actions of strikers, strike sympathizers, and labor agitators.

Power and Fuel.—Power and fuel are employed by practically all manufacturing plants. When the consumption of power is great, as it is in certain industries, low cost may be the controlling factor in deciding on a location. Data should be secured relative to: (1) the proximity of coal mines, oil fields, or gas pipe lines, and natural gas; (2) cost of transportation from each; (3) public utility service; (4) competition; (5) rates; (6) possibility and desirability of developing local water-power sites. Comparative estimates may then be made, covering power and fuel expenses for different localities.

Changing Sources of Power.—When water power was the principal force utilized to turn the wheels of industry, the small factories of the period were concentrated along swift-flowing rivers. In this country the rivers and streams of New England afforded the best available sites, and as a consequence American industry developed in that area. Today, electric power has made this situation obsolete and has brought a decided decentralization in industrial locations. It is now possible to transport electric power economically for several hundred miles from its source. Factories, as a consequence, are enabled to choose sites with

reference to other considerations. The decentralizing effect on industry has been noticeable, for example, in the Piedmont region of the Carolinas, and elsewhere in the South, in New England, Pennsylvania, California, Washington, and, in fact, throughout most of the nation.

The national government has undertaken development of projects in Tennessee, Nebraska, Montana, Washington, and other states which will result in the production of large quantities of power which it is hoped can and will be utilized for industrial purposes. Fairly low power rates have been established. Some of these projects involve other considerations such as flood control, navigation, irrigation, community betterment, and raising of ground water levels. The extent to which the cost of the projects is reflected in rates for power depends upon the proportion of cost charged against these other benefits.

Industries Requiring Cheap Power and Fuel.—Those industries dealing with raw materials which require the use of heavy machinery seek cheap power. Primary manufacturing operations are often of this kind, as in sawmills, flour mills, steel mills, wood and metal working plants, those utilizing electric furnaces and electrolytic processes of refining metals. Electro-chemical and abrasive plants cluster about Niagara Falls. The Aluminum Company of America has established plants in the Tennessee Valley area.

The need of intense heat in carrying on industrial operations suggests nearness to a fuel supply. Cheap fuel is an essential in making brick, cement, glass, clay, and porcelain goods, the production of iron and steel, and in the metallurgical and refining industries. The relative weights of clay, finished product, and coal are about 40, 30, and 3, respectively, in making brick. Money-making brick plants usually have shale, fuel, and a market in close proximity to each other. At Danville, Illinois, a 6-foot vein of coal underlies a bed of clay and shale about 45 feet in depth, all of which is readily handled with steam shovels. This affords an ideal combination of materials and greatly extends the competitive market range for the product. Likewise raw materials and fuel in conjunction with a nearby market are the essentials to profitable cement operation. The glass industry at Pittsburgh, in Indiana, Illinois, and Oklahoma is located with reference to fuel supply. An Illinois zinc company has recently moved its smelting operations to the Texas Panhandle, a thousand miles or more nearer its ore mines, and where natural gas is available at a much less cost than Illinois coal, even though the company owned its own mines.

Transportation.—Industries seek sites in localities favored with adequate transportation facilities. Of consequence are: (1) the number of

railroads available, (2) the service rendered, (3) convenient trunk line connections, (4) water transportation, (5) electric lines, (6) motor transport, and (7) rates. So far air transportation has not played any considerable part in deciding the industrial location problem, but its potentialities must be recognized.

Railway Rate Structure.—Transportation service and rates are important considerations in the assembly of raw materials and the distribution of goods. More than any other one factor transportation limits market areas. To locate ideally with respect to raw materials and market, so that the combined freight charges will be lowest, involves a knowledge of the basis upon which rates have been developed.[1]

Our present rate structure is an outgrowth of many conflicting factors, among which are precedents, cost of service, length of haul, value of commodities, competition, unbalanced traffic, desire to develop localities and industries, volume and perishability of goods. Early water and rail competition established low rates which remain as a part of our rate structure, even after water competition had lost its effectiveness. Although often inequitable, existing rates have built up regional industry, and commerce has established itself in accordance with them.[2] To change existing rates radically would alter seriously the industrial map, change channels of trade, and jeopardize tremendous investments in physical plants.

The rate structure is not inflexible, however, and traffic counselors and others interested seek and secure modifications favorable to new and expanding business interests. In this way inequitable situations are gradually overcome and progress is made.

A central Illinois manufacturer with a newly acquired branch plant in Tennessee found that shipping costs from this branch totaled higher than if made from the Illinois plant, even though the bulk of shipments were to the south and southwest. Government agencies have recently pointed out that industrial development of the area in which the Tennessee Valley Authority is interested will necessitate an adjustment of freight

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[1] As an illustration: Rates "break" at St. Louis and upper Mississippi River points. That is, shipments from points east of the Illinois-Indiana state line to territory west of the river are subject either to full combination of separate local rates east and west of the river, or to fixed differences over rates from river points to the West and Southwest. St. Louis shippers, for example, would thus enjoy the lower basing rates against their long-haul competitors.

[2] It is interesting to note that Muskegon, Michigan, enjoys less than Chicago rates to Atlantic Coast points and Chicago rates to all Pacific Coast points. This fact, together with the advantageous labor situation as compared with Chicago, nearness to raw materials, favorable climatic conditions, etc., has favored industrial growth. Coal from Kentucky is favored by low through rates, and is marketed in Chicago in competition with Illinois coal. Brick from Alton, Illinois, is marketed in Nebraska, North and South Dakota, and other states, due to favoring through rates.

rates to the north and east. The present structure of rates favors commodities moving into the area and handicaps those moving out.

Recent Developments in Railway Transportation.[3]—The competition for freight traffic among the several transportation agencies finds the railways making substantial progress. Operating costs of transporting freight have been steadily reduced. In 1921 this cost was $10.78 a thousand miles; in 1929, $7.44; and in 1935, $6.63. In a recent modernization program the Pennsylvania Railroad was able to handle more freight than formerly with 22,000 fewer cars. This was possible due to larger cars, faster schedules, and a reduction in time for yard and terminal operations. While freight movements have been speeded up by more than 60% in the past decade, rates have been decreased from more than 1¼¢ per ton-mile to an average of less than 1¢. Special car equipment has been provided for many commodities, facilitating shipment; and portable steel containers provided for less-than-carload freight. Door-to-door pick-up and delivery service has greatly increased the volume of small lot shipments. Electrification in areas of traffic density permits faster hauls, heavier and longer trains, and thus increases the capacity of a given amount of track. Altogether, transportation efficiency has been more than doubled in the past 20 years. A continuing place for the railroad in industrial America is assured.

Benefits of Competing Service.—Competition in service is desirable, for the manufacturer is apt to receive better service and enjoy lower rates than he would otherwise. A location on a belt line railroad connecting with several trunk lines provides competition and eliminates local transfer charges. On competitive traffic, switching charges are absorbed, while on local or non-competitive traffic they are added to the rate.

In Chicago, industry is served by an inner belt line and an outer belt line railroad, which connect with the thirty-eight railroads having terminals in the area. Incoming freight from any source is handled over the belt line to the receiving door of the plant to which it is consigned; and vice versa, loaded freight cars are transferred to the proper outgoing road. Belt lines expedite freight movements and save switching charges. Another example of a belt line railroad is that of a line extending in an arc from South Bend, Indiana, on the east, through Kankakee, Illinois (south of Chicago), and to Zearing, Illinois, on the west. This railroad crosses about three-fourths of the country's main transcontinental routes, and thus affords a ready outlet and inlet for commodities produced or needed by industries in its territory.

[3] The Girard Letter, published by the Girard Trust Company, Philadelphia, Vol. 17, No. 2.

Package Car Service.—The larger cities and organized industrial districts have developed a "package" car service which does much to expedite less than carload shipments and provide customer service. All goods consigned to certain points are loaded into special cars, thus providing carload shipments and direct fast service to those points. Where it is necessary to include shipments for two or more towns in one car, local trains pick up these cars at break-bulk points.[4]

Water Transportation.—Experience in the United States and European countries indicates that railways naturally supersede rivers and canals as carriers of manufactured goods, and, to a very great extent, of raw materials for manufacture. This situation has come about in Europe where railway freight charges are much higher than in this country. The rapid development of highway truck transportation would seem to preclude any considerable development and use of rivers and canals. However, a large volume of freight is transported on the Great Lakes.

The New York Barge Canal connecting the Great Lakes at Buffalo with the Hudson River at Albany operates at a huge loss to the taxpayers. The same is probably true of the Ohio River and most other natural waterways if all the costs are taken into consideration. However, the possibility of utilizing the projected Great Lakes-St. Lawrence waterway and the Lakes-to-the-Gulf channel for export and import shipments and long distance haulage of staple goods should not be overlooked. In the development of these channels, water power will be made available as well as cheaper transportation, lowering production and distribution costs appreciably. Coordination of our coastal shipping facilities and interior waterway traffic with railway and motor truck lines is important, to secure cooperation rather than competition. Scientific procedure along this line is essential to a comprehensive transportation scheme which will make possible the moving of the nation's goods at the lowest possible sum total of cost.

Highway Transportation.[5]—Of rapidly increasing importance is the growth of motor transport service. Networks of paved highways about our larger cities and extending from coast to coast are being utilized for inter-city and local shipments by truck. Transportation of freight by trucks is economical for distances up to 500 miles for most commodities; and some regular shipments are scheduled for much greater distances. Butter and eggs from the Middle West go to New York and eastern

[4] Chicago reports that 2,500 package cars leave that point by through freight each day.

[5] The literature of industrial districts calls attention to the population and markets which can be served by motor truck service. Within a two-hour trucking radius of the port of Newark, New Jersey, for instance, is included the entire metropolitan district of New York and a population of nearly ten million.

markets via truck. Perishable fruits and vegetables are hauled from 500 to 1,500 miles. Automobiles from Michigan are trucked for distances of 1,500 miles. Where comparisons may be made between highway and river transport, it is found that truck deliveries are made in 10% of the time required by water and with a saving in mileage of about one-third.

The advantages of shipping by truck are summarized as follows:[6]

Completed Service—From the shipper's place of business to that of the consignee.

Speedier Service—In many instances truck service is speedier than the railroad. Is likely to be faster than rail express service up to distances of 150 miles, but is inferior to such service for distances exceeding 350 miles.

Packing Requirements—Truck shipments generally require less packing; sometimes no packing.

Flexibility of Service—More convenient. Many shipments may be made at night for early morning delivery, or as desired.

Lower Cost—Trucking costs and trucking rates are often less than rail rates, particularly for shorter hauls. For long hauls truck rates naturally exceed rail rates.

Less Loss and Damage—Less than for rail or express shipments.

Simpler Classification and Rates—Easier to determine classifications and figure rates.

The possible disadvantages of truck transportation include: (1) less dependability of schedules, (2) less responsibility of owner of lines, (3) less stability of rates, (4) less adequate protection and care of goods in transit and at delivery points, and (5) lack of intransit privileges. It is reasonable to assume that many of these disadvantages will be substantially overcome as the service is developed. Where owners provide their own service, most of them will be eliminated.

Express, Parcel Post Service, and Airplane.—Express service attracts the heavier, more valuable package business. The express companies provide a pick-up and delivery service, with receipts, and a C. O. D. service as well. They also insure against partial and complete loss for any amount up to $50 for 100 pounds or less and a declared value of 50¢ per pound on larger shipments, without extra charge. Parcel post service is cheaper for short distances and for articles light in weight, for any distance. Upon payment of a small fee packages may be insured against total or partial loss for values up to $100. Express

[6] Economics of Transportation, by David Philip Locklin, p. 734.

service is considerably faster than parcel post and packages are handled with greater care and less resulting damage.

Freight and express shipments via airplanes are increasing for items of small bulk and high value. Even large shipments are possible, and the future of air transportation can scarcely be overestimated. Where long distances and difficult terrain must be covered quickly the airplane is frequently the best means of conveyance.

Table 1 gives some comparative costs of express and parcel post shipments.

TABLE 1. COMPARISON OF EXPRESS AND PARCEL POST SHIPPING COSTS

Weight of Package	From Urbana, Illinois to: Chicago (126 miles) Express	Chicago (126 miles) Parcel Post	New York (1,025 miles approx.) Express	New York (1,025 miles approx.) Parcel Post	Los Angeles (2,375 miles approx.) Express	Los Angeles (2,375 miles approx.) Parcel Post
1 pound	$ .25	$.08	$ .25	$ .11	$ .30	$ .14
10 pounds	.30	.18	.65	.59	1.10	.95
40 pounds	.72	.51	1.84	2.18	4.68	3.65
50 pounds	.90	.62	2.28	2.71	5.07	4.64
100 pounds	1.60	..	4.29	...	9.93	...

(The express rates include the usual insurance protection.)

Legislation.—National legislation which establishes uniform wages and hours may have some effect on industrial location, particularly in the South where low wages and long hours were formerly the rule. A more direct influence is exerted by state legislation which affects costs of production and influences sales prices and distribution between territories. It is important, as it deals with: (1) hours of labor, (2) employment of women and children, (3) minimum wages, (4) conditions of employment, (5) workmen's compensation, (6) liability of employers, and (7) taxes.

With our system of independent state laws, unfriendly legislation may impose a handicap upon the industry of one state as against the competing industry of other states. In one middle-western state taxes and labor difficulties have caused manufacturers either to move out or to build branch plants elsewhere. In some cases reorganizations are effected so that production organizations in the state sell at cost to separately incorporated sales organizations located outside. By this arrangement objectionable taxes on profits are avoided. An important eastern state recently experienced a similar serious exodus of plants. In this instance it was possible for many plants to move but a few miles

into industrial localities of border states. On the other hand, certain other states are seeking to attract industry by favorable legislation. One southern state offers tax exemption for 10 years, and assurance of a friendly government.

City Ordinances.—Municipalities are tending to segregate industry by zoning laws. This practice leads to certain areas being laid out and equipped for manufacturing, and obviates the possibility of future oppressive ordinances on account of proximity of business and residential sections. An industry which is properly housed and located is a community asset and will be so regarded. Oppressive ordinances, useless inspections, zoning limitations, and traffic problems cause industries to leave city areas.

Climate.—In some parts of the country the winters are long and cold; in the deep South the hot summers are to be considered. The South enjoys an hour more of sunshine than the North during the winter months, while in the summer the days are shorter.

Automobiles and highways now make it possible for executives and employees to live in favored residential or rural areas within a radius of 25 miles of the place of employment. Air conditioning of factories and offices for comfort as well as for quality control is becoming general.

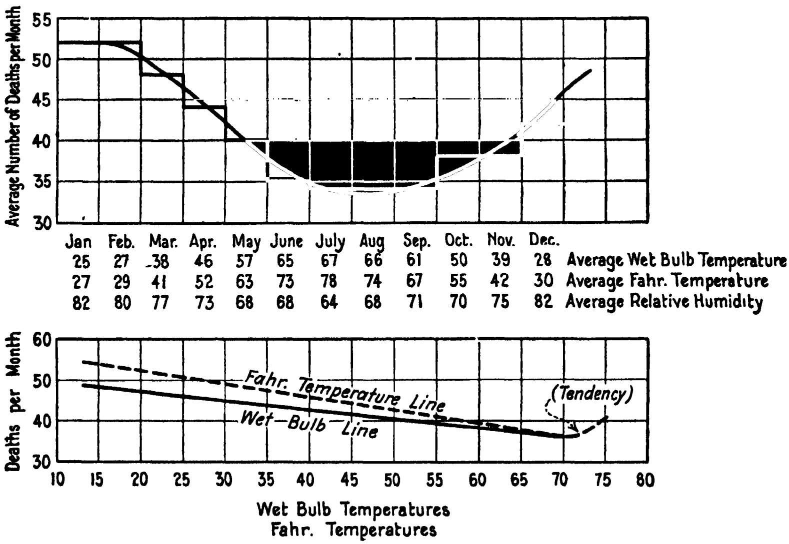

Figure 20. Effect of Temperature on Death Rate

(Data from Champaign County, Illinois, Weather and Death Records, ten-year period.)

Again, it is well to appreciate that the people of a locality become acclimated. Ineffective labor supply in the past has frequently been due to insanitary arrangements, inadequate medical service, and low standards of living, rather than to climate deficiencies. On the whole, the industrial areas of the United States are favored with an excellent climate, and some localities are particularly fortunate in this respect. While extremes are to be avoided, constant variability within moderate limits contributes to personal effectiveness. "Each storm with its changing skies, varying humidity, and slow rise and rapid fall of temperature, is a stimulant. Each raises our efficiency."[7] Climate may also influence the type of building construction and heating system installed. Hence it will have some bearing on operating costs.

While the ideal climate does not exist, an approximation would be a locality whose winter months are favored with frosts, and where the temperature of summer days approaches 70 degrees F. Figure 20 shows graphically the relation between climatic conditions and health in a midwestern community and presents data of weather conditions which were conducive to a favorable death rate.

Water Supply.—Water plays an important part in many production processes, and the plant which is dependent upon a considerable supply, and perhaps a certain purity, will need to ascertain the local possibilities. The water may be obtained through public service mains, or by drilling private wells or constructing reservoirs. In any event its cost will need to be determined, its quality analyzed, and the extent of the supply ascertained. Soft water is required by leather tanning plants and many others. An adequate water supply is an essential in choosing sites for corn products plants, paper plants, and ore reduction works. For these plants the water supply is important both as regards quality and quantity. For example, glucose syrups are rendered cloudy if sulphur is present in the water.

The Hiram Walker & Sons distillery at Peoria, Illinois, pumps about thirteen million gallons of water each day from cold, limestone-bearing strata. The temperature of the water—from 48 to 52 degrees—is an advantage in operations, and the limestone base contributes to the quality of the product.

For the development of steam power a great deal of water is needed; 500 to 1,000 tons of water per ton of coal used. "For certain industrial purposes, especially in the textile field, water should be free from turbidity; low as possible in organic matter, iron, manganese, or alum; and of zero hardness. Soft fabrics dyed in delicate shades demand water

[7] Civilization and Climate, by Ellsworth Huntington, p. 123.

of the utmost purity; the clearness and brightness of the colors, even the feel of the goods, improves with the purity of the water. Penetration of the dyestuffs into the fibre; uniform results from batch to batch; productions of desired shade with a given dyestuff formula; avoidance of redyes; fastness of colors—all of these are dependent upon a chemically pure water supply. Clarification of any water supply by filtration costs an industrial plant from two to five cents per thousand gallons of water purified." [8]

THE LOCAL SITE

Choice of a Local Site.—Of the many manufacturing enterprises which are well located geographically, perhaps 50% could be better situated locally. After the general location problem has been solved there still remains the opportunity to choose between: (1) a rural location; (2) a suburban site; and (3) a city location. The range of choice may even be increased by consideration of the varying sectional advantages of a city, the adjoining industrial towns—which are really a part of it—and privately organized and controlled industrial districts.

Factors Influencing Choice of Local Site.—Influencing factors in a choice of a local site are: (1) land values; (2) character of site—that is to say, the contour of the ground, soil conditions, and the shape of the plot; (3) room for expansion; (4) public improvements, such as sewers, power lines, water and gas supplies, pavement, and transportation facilities; (5) trackage and shipping facilities; (6) presence of smoke, dust, dirt, odors, or noise; (7) adequacy and character of the labor supply; (8) disposal of waste; (9) taxes; (10) building restrictions; and (11) express and postal service. In addition there may be added the questions of raw material sources and local market, as in the case of a food products plant dependent upon packing house by-products.

In small towns and rural communities the solution may be fairly obvious, but the experienced investigator with a thorough appreciation of production problems and costs frequently is able to make some unlooked for and valuable suggestions. In the larger industrial centers, the problem assumes a complicated form and requires an intimate acquaintance with existing conditions.

Rural Locations and Small Towns.—A rural or isolated location may be sought by the large plant independent of other industries, capable of creating its own environment and with little interest in local

[8] "Industrial Advantages of a Paterson Location," by Herbert S. Swan, booklet issued by the Industrial Commission, City of Paterson, New Jersey, p. 37.

markets. Cheap land, low taxes, absence of building and operating restrictions, room for expansion, opportunities for creating ideal production arrangements, and greater freedom from radical labor influence upon employees are strong appeals. The building of independent communities is an expensive task, with many obstacles in the way of success. The responsibility of the management for the workers' welfare is greatly increased, but the provision of ideal surroundings and opportunities for "living" to the workers and their families should develop a loyalty and cooperation not measurable merely in dollars and cents. To this end, freedom of thought and action must be enjoyed by the worker, and opportunity to own his own home, and steady employment at an adequate wage. Paternalistic control and direction is almost certain to prove objectionable. Cooperation which helps the workers to help themselves is more likely to succeed.

Small plants moving to country towns should plan ahead carefully and provide in advance for housing and improvements to which city workers are accustomed. The experience of a band instrument concern, in moving from Chicago to a small Wisconsin town, is enlightening and perhaps typical. The management reports very satisfactory freight, express, and mail service for the business. Considerable difficulty was at first experienced in providing living quarters for the 40 or 50 families which they took with them, and they were required to build 27 new homes. Living costs were not much cheaper and wages were not lowered. Later, wages were increased, the intimate contact of management and men and the improvement in morale making it possible to handle twice the business with the same number of people. They report a waiting list of skilled workmen desiring to move to a rural location. Certainly the lure of the city has lost much of its potency as a result of widespread ownership of automobiles and radio sets, universal movies, and paved highways.

In an article entitled "Should Factories Go Back to the Farm?" W. R. Bassett quotes the views of a number of factory executives.[9] Points brought out are these: Paternalism is not a substitute for wages; labor is tied to the employer in the small town; seasonal industries encounter difficulties on account of the labor supply; costs do not stop when plants are shut down; and farmer labor in factories, intermittently, is not a success. However, the characteristics of a small town labor supply are generally favorable. They include health, thrift, ways of living which do not tax physical or nervous powers unduly, intelligence, and capability in connection with mechanical tasks. A background of farm life

[9] "Should Factories Go Back to the Farm?" by W. R. Bassett, *Factory Management and Maintenance*, Vol. 26. No. 12, p. 1381.

with its extensive use of farm machinery seems to provide a good preparation for many industrial occupations. Many small isolated plants are being operated successfully. Workers may live nearby or in the countryside, and include many who would not otherwise find profitable employment.

City Locations.—The big city location is apt to be characterized by just the opposite of conditions favoring the country location. Land will be costly, taxes high, building codes and ordinances restrictive, room for expansion unobtainable, and radical leadership of workers a factor to deal with. Nevertheless, an analysis of the essentials for economical production and distribution will indicate that the city location is preferable in many instances. An ample local market, diversified and seasonal labor supply, public utility service, nearness to the business center, and allied industries are often of major importance. Small factories seek space with others and an opportunity to benefit by the industrial environment which large institutions have created.

In a city like Chicago, for instance, the labor needs of a plant would influence very greatly its location; likewise the nature of the production operations carried on, the extent and character of its incoming and outgoing shipments, advertising value of the plant, etc. Light manufacturing operations seek sites adjacent to residential districts, housing themselves in attractive buildings to minimize neighborhood opposition. Engraving plants, pen and pencil manufacturers, and various specialty enterprises are examples. They provide employment for many women workers. These women will not seek work in the regular industrial districts, but accept employment and prove unusually capable when pleasant work nearby is offered. Such an arrangement is conducive to a satisfied, contented, and hence efficient staff, the most important factor in the production machine.

Suburban Locations.—The suburban location affords a compromise between the city and country location. The medium-size plant is quite apt to locate there. Nearly all of the advantages of city location are present, including shipping facilities, proximity to labor supply, public utility service, nearness to allied industries and the local market. Land will be cheaper, taxes less, and room for expansion available. The small industrial towns adjoining many of our large cities are indicative of the tendency to move out from the congested centers and seek the advantages of suburban location. Unfortunately some of them are simply "work towns" without much thought expended for the well-being of employees and their families. A greater interest by industrial executives in civic improvement and the maintenance of conditions conducive to a

high standard of citizenship will do much to improve some of these towns as well as to lower production costs. Workers reflect their environment in their work and attitude toward the company. Furthermore, each person on a payroll—in the estimation of some politicians—influences from twenty-five to forty votes; and this force in community affairs is important indeed to business and industry. Care should be exercised in choosing a locality which, satisfactory in other respects, is not deficient in the matter of public attitude. If so, policies of administration and management should prove a corrective influence, for business and industry merit public approval.

Waste Disposal—Topography of Site.—Disposal of waste at a low cost or even at a profit may sometimes be accomplished by judicious choice of site. Low ground may be filled in and made valuable. A foundry in Michigan provided for a finished grade 5 feet above the natural ground level, in this way converting otherwise unusable ground into a valuable area. Another factory availed itself of the clay pits of an abandoned brickyard as a dumping ground. Sanitary regulations are becoming more stringent, and streams may no longer be polluted. Paterson, New Jersey, has solved the problem of waste disposal for its industries through the construction of the Passaic Valley Sewer. Restrictions upon waste disposal which necessitate altering processes or the installation of treatment plants add to costs.

Unusual topography may permit entrance to a plant on different floor levels, reducing cost of handling heavy and bulky materials, and facilitating straight-line production. The shape and placement of a site determine layout possibilities, location and space needed for rail sidings, traffic hazards and difficulties, and accessibility to offices.

Organized Manufacturing Districts.—The privately organized and controlled industrial districts have much to recommend them. They are to be found in most metropolitan areas. The Bush Terminal in Brooklyn, the North Kansas City Industrial District, and the Central Manufacturing District and Clearing Industrial District in Chicago are typical of many. Those at tide water naturally appeal to industries manufacturing for export or coastal trade, utilizing imported raw materials or products from nearby industries, or perhaps catering to big city markets nearby.

Central Manufacturing District of Chicago.—The Central Manufacturing District of Chicago offers a good example of a privately operated industrial community. It offers manufacturers and distributors every modern facility for successful operation. It is in the center of the Middle West and of national markets. Situated close to the geographic

center of Chicago, it possesses every advantage in the matter of local distribution. The Chicago Junction Railway, a belt line connecting with all the 38 trunk lines entering the city, provides railway service. Every factory has its own private switch track, and is given free switching on both carload and less-than-carload freight, whether inbound or outbound. Outgoing shipments of less-than-carload freight are taken to the Union Freight Station and distributed to the various railroads, where package car service is received and dispatched through the Union Boathouse on the Chicago River, or from railway sidings, and in addition locations may be had with water frontage.

The location of the district close to the population center is also an advantage for the manufacturer. Within a radius of four miles there is a population of a million and a quarter, and within easy walking distance are several labor sections that are noteworthy. These contain German, Lithuanian, Polish, and other nationalities, and in them are resident thousands of young, intelligent workers born or educated in this country. The location of the stockyards close by, employing men workers almost entirely, suggests the plentiful supply of women workers available.

Intelligent and experienced aid is given in building factories ready for occupancy. This includes the scientific planning of both the site and the building by industrial specialists, the dependable construction of the building, with every consideration for efficiency, and the financing of the project if desired. The efficient layout of the ground in itself insures that an industry in this district will be in a zoned section where the buildings are all of substantial, attractive character, and where there will be no lines represented which are in any way objectionable. There are ample light and air for each building, with lawns, flowers, and healthful surroundings. The streets are owned by the district, are paved and lighted, and sewer, gas, water, and fire hydrant services are provided. Suitable buildings are built and rented for a term of years, the rent charged amounting to 6% of the value of the land and 9% of the value of the building; insurance, taxes, and maintenance are added. Or buildings are built and sold on a purchase contract which requires a payment of 25% down and the balance spread over 10 or 15 years. Speculation in locations and land values is eliminated.

A traffic bureau has been organized by the industries in the district which attempts the solution of all the traffic problems of the members and whose work has been particularly notable in securing the operation of all the truck lines in the interest of the local shippers.

In one section of the district there is a group of buildings in which the tenant may secure central heat from a power plant equipped with

every modern device, at a cost lower than he could hope to produce it. He can also secure central sprinkler service, thus avoiding the necessity of installing his own sprinkler tank and pump and evading the responsibility of his own individual supervision and care of this equipment. He can also secure a tunnel connection with a nearby universal freight station through which his less-than-carload shipments and receipts can be handled expeditiously. Shipments to and from the station are moved on the trucks and trailers which he uses in his own warehouse or factory.

In the vicinity a bank is available which offers local service of a high character and possesses an understanding of industrial needs. Nearby also is an executives' club which provides excellent restaurant facilities, private dining rooms for business engagements, and a lounging room as a convenient rendezvous for business appointments. Special district service is provided in the way of express, telegraph, telephone, postal, and hospital facilities. Electric power may be purchased from competing companies at very favorable rates. Insurance rates are low owing to the character of the buildings, their arrangement, and the protection furnished.

Technique in Solving Location Problems.—The executive needs to know or anticipate the total costs of doing business in one location as compared with others. These may be calculated as follows for a given volume of output for a month or year; or per unit of production, as a barrel of cement, ton of castings, or 1,000 of brick.

Volume of Product	
Cost of raw materials .... (Includes purchase price at logical sources for the location considered, plus transportation charges to site.)	$ . . . .
Cost of manufacture .... (Includes all operating and overhead costs, as salaries, wages, interest on investment, taxes, insurance, power, depreciation and obsolescence.)	$ . . . .
Cost of marketing .... (Distribution costs for all goods produced can be estimated from experience or on the basis of market analysis.)	$ . . . .
Total	$ . . . .

Comparable estimates for several possible locations will disclose the one which is most strategic. Needless to say, skill and judgment are requisites to analyses which reflect accurately the factors involved, especially future trends. Some influencing forces cannot be reduced to figures, and will need to be considered separately, as possible legislation, labor developments, adequacy of raw materials, technological progress, and shifts in the market.

Those thoroughly experienced in industrial operations are frequently able to give consideration to the factors involved by "weighing" each factor in accordance with its cost influence. A background of cost information obtained from individual establishments and through trade associations aids in evaluating their relative importance. For example, power costs might have a weight of 20 points in a total of 100. A prospective location receiving the greatest sum total of points, all factors considered, would presumably be the most advantageous.

The census of manufacturers divides industries into about 350 classifications. At least 130 of these are found to be dependent upon low cost power and labor, or both, as these factors make up over 50% of the cost of production. About 50 of these industries would need to be located near raw materials. About 80 of them would be free to choose a location on the basis of power, labor, and transportation facilities.

Various engineering and consulting agencies are prepared to make studies and render reports in this field. State and regional commissions, railroads, and chambers of commerce are prepared to furnish information and specific data on particular locations.

Governmental Influences on Industrial Location.—The National Resources Planning Board was a Federal agency created to study and plan for the development and best utilization of natural resources in the various areas of the country. Until abolished in 1943 plans for regional improvement were formulated through a system of field offices, and an endeavor made to unify and balance industrial production on a national scale. These efforts will be continued through other governmental agencies. The objective is to promote, all things considered, the best local, regional and national development. In this work state groups also play a part. The State Planning Commissions give thought to the location, diversity, and extent of manufacturing in particular areas, and the problems which have resulted from existing maladjustments. Likewise, local organizations have been created to aid in solving the problems incident to overcentralization and specialization of industry in particular localities, as the Mahoning River Valley in Ohio, and the Detroit area. Functioning as fact finding and advisory groups they give aid in bringing about the healthy economic environment needed as a basis for social well-being. Individual industrial management utilizes the information made available in reaching decisions as to desirable locations.

CHAPTER 9

PLANNING THE FACTORY BUILDING

The Building as a Tool.—The provision of buildings is an important phase in the business of manufacturing. It is naturally a task which occurs at the inception of the enterprise, but it is not merely a preliminary step which must be taken before manufacturing can begin. Planning the factory building is the first aspect of layout and tooling work, and should be regarded in this light. Just as the smaller tools and general layout fulfill a particular function in the production of the finished product, so does the plant building by its design and arrangement function to make production easier or more difficult.

While the plant building is, of course, constructed prior to actual manufacturing processes, its design should be formulated only after the details of the manufacturing process have been worked out. The building is an organic and integral part of these processes. Since this fact has become evident progress in building design has made great strides. Specialization of manufacturing processes has brought with it specialization in building design suitable to house those processes, and this has increased the difficulties and complexities involved in planning a building. For this reason the executive charged with the task is frequently perplexed.

In handling the problem the executive can turn either to his own staff, to architects and engineers, or to recognized specialists in this field.

Use of the Plant Organization.—It is seldom advisable for the factory executive to use his own staff in making plant extensions. It must be recognized that the building industry is a highly developed business, requiring the close coordination of many specialized groups, and the intelligent, experienced efforts of men trained in the business. Factory executives, draftsmen, purchasing agents, superintendents, foremen, and workmen invariably prove novices when handling unfamiliar tasks. The functions performed may be the same, it is true, but the experience called for and the technique involved are radically different. Even building laborers are semi-skilled, and a factory worker on a building job seldom proves more than 50% efficient. Differences in accomplishment are equally noticeable among those higher in the organization. On unusual work of this kind it is difficult, if not impossible, to establish and maintain standards of performance or even to make cost

comparisons, and expense may mount to a high figure before becoming apparent. This inability to check costs extends to materials and administration as well as labor, for experience will be lacking in selecting and purchasing materials and in solving the multitude of problems which arise.

Every contractor realizes the great importance of careful preplanning, successful coordination of the various trades and phases of the work, and skilled direction of the workmen. Lack of judgment and ability in these respects increases job costs enormously, and the industrial executive may well leave the task for those who are in the business. There is probably no other industry in which low labor costs are so dependent upon the skilled choice and direction of workmen, or where costs may double or even triple without apparent reason.

Observation and experience indicate that building programs handled in this way take much more time and attention from all concerned than was anticipated. They inevitably disrupt the routine production interfere with service to customers, and take the time and thought of executives with resulting confusion throughout the organization. Few firms which maintain construction crews for repairs and maintenance attempt to handle major operations. They have found that the specialized talent required is found in particular organizations and that the use of this specialized service pays dividends on its cost.

Services Offered by Architects and Engineers.—The employment of an architect usually provides for the preparation of plans and specifications, the letting of general contracts, and the supervision of construction. In this way much of the responsibility is delegated to qualified men. Strictly speaking, however, the design of factories has little relation to general architecture. To handle the task requires a thorough knowledge of the production processes to be cared for, and an understanding of factory management and production control, including an appreciation of the reaction of the workers to the equipment and facilities provided. These subjects are foreign to the training of the typical architect. It is scarcely possible that he will look upon the task as that of fitting a housing scheme to a production machine—which he has also designed or at least analyzed and checked carefully—so that it will function as a part of the machine itself. This is a decidedly prosaic, utilitarian, dollars-and-cents-balancing job, calling for a wide range of engineering and production talent, and an understanding of the psychology and needs of labor. Architectural design will prove to be a minor feature. If the architect acts mainly as a draftsman in carrying out the owner's ideas, the owner is failing to secure the benefit of much concentrated

intelligence in such matters which is available, and which his fee to the architect might well obtain for him.

It may be that the architect has outgrown his title and perfected an organization capable of serving an industrial clientele in the manner suggested. There are many who are thus capable, but it is very disconcerting to the factory executive, who imagines that all architects are conversant with and proficient in industrial building design, to find out too late that he is mistaken. Many engineers, because of their restricted training, experience, and practice, are subject to the same criticism as many architects as regards ability to handle industrial projects in an adequate way.

It has been well said that industrial plant design has passed through three stages. The first stage was when factories were housed in "just buildings"; the second, when architecture was employed to improve the appearance of such structures; and the third, the present stage, when industrial buildings are designed to "fit the processes" carried on within them, and form an integral part of the production scheme. Many such recently constructed plants may be looked upon as in themselves "big machines" containing and coordinating all the "little machines."

Specialists in the Field.—It was inevitable with the increasing importance, progress, and keener competition in industry, that there should develop specialists in industrial layout work, building design, and construction. Firms handling work of this kind operate under various names, and firm titles are not a sufficient identification or assurance of satisfactory service. The inquiring industrial executive must know the character of their personnel, the results which they have achieved, and their methods of getting results, if he is to judge the probable value of their service to him. Certain firms, because of the volume of business which they have handled in connection with the metal trades industry, the textile industry, etc., have practically become specialists in those lines, but usually firms of this character are capable of handling factory engineering problems in almost any industry.

Preliminary Work.—The procedure involved in engineering a new plant is suggested by the following steps.[1]

1. Compilation of basic information.
2. Process design.
3. Estimate of cost.
4. Specifications—materials, equipment, and construction.
5. Design for construction.

[1] "Engineering the New Plant," by Thomas W. Hopper, *Factory Management and Maintenance*, Vol. 96, No. 4, p. 60.

6. Selection, purchase, and delivery of materials and equipment.
7. Construction.
8. Preliminary operation.

The work involved in the first two steps may be performed or shared by the owner's organization, or if desired, undertaken by the engineering organization. Responsibility for the succeeding steps will rest with the latter organization, subject to advice and approval from the former.

Some firms of industrial architects and engineers do not engage in actual building operations. Such firms would supervise the taking of bids and letting of contracts for the owner, and provide the needed supervision and control of building operations. For small projects a general contract would be awarded, and the necessary inspection and supervision provided by representatives from the central office. For larger projects a different plan is often used to advantage. Instead of a general contract to a firm who would in turn let sub-contracts covering different phases of the work, contracts are awarded direct to those who will do the work. A resident engineer who is paid by and represents the owner is then placed on the job. His task is to coordinate the work of the several specializing contractors, to supervise construction operations, and to expedite the work. In this way pyramiding of costs by the inclusion of profits for the general contractor on the work of sub-contractors is avoided. The resident engineer reports to and cooperates with the architect's office, which awards all contracts subject to the owner's approval, audits bills, and looks after clerical and detail work. The owner and his organization are relieved of unfamiliar duties in connection with the project, depending upon those who are expert in this field.

It is important to note that with this method the architect functions in a strictly professional capacity, having only the owner's interest to conserve. He does not sell construction labor or materials, and his compensation consists solely of a fee or per cent of cost, as previously agreed upon. When an owner tells such an organization what he wants to manufacture and in what quantity, they will create an efficient plant for the purpose, fully equipped and ready to operate, and if desired, will provide operating assistance until the plant is functioning smoothly.

Standard Factory Buildings.—The possibility of furnishing many different customers with buildings of the same kind led to the introduction of factory-made industrial buildings. At the present time there exists a considerable latitude in the choice of sizes and designs. Leading firms in this field also maintain architectural and engineering staffs to design special structures, or at least to adapt standard designs to the

individual needs of clients. A leading firm sets forth the following advantages of standard building service:

> A method of erecting permanent and substantial buildings in the fewest number of working days—eliminating by standardization and quantity production delays otherwise unavoidable.
>
> A method which provides for various industrial types of construction by standardization of designs and specifications. The time ordinarily required for the preparation of special plans is saved.
>
> A method of pre-construction work which prepares and holds stocks of fabricated steel, steel sash, roofing, lumber, and other materials at strategic points and delivers them to any job with dispatch.
>
> A method of figuring costs which places the production of industrial buildings on a definite price basis by any form of building contract the owner may prefer.
>
> A method which delivers a thoroughly satisfactory building, meeting every requirement of the business with the least expenditure of the owner's time and money.
>
> We design, build, and equip factory buildings and industrial power plants, complete with all machinery, ready for operation, according to our plans and specifications as approved by the owner.
>
> This method of placing the entire responsibility for a finished structure with one organization has proved over a long period of years of practice to have many advantages:
>
> 1. It is usually more economical to have one contract and one responsibility.
> 2. It insures better coordination of engineering design, construction, and purchasing of materials and equipment.
> 3. By uninterrupted progress of the work, it insures an earlier completion date for useful occupancy of the structure.
> 4. It eliminates possible arguments as to responsibility. Arguments cause delays and are often costly.
>
> We also make surveys of plants including buildings and equipment, reporting to owners our findings and conclusions as to possible needs of replacements, additions, or revisions in structures or equipment.
>
> We guarantee price, delivery date, quality of workmanship, and materials.
>
> We will furnish quickly and cheerfully, preliminary sketches and estimates, free of cost or obligation.[2]

A factor which carries much weight with an owner is that he may in one contract place full responsibility for the project in its entirety, and at a stipulated cost.

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[2] The H. K. Ferguson Company, Cleveland, Ohio.

Firms in this field act not only as architects and contractors, but as merchants. When a client's needs cannot be met with a standard design, modified or special designs are prepared.

The advantages of standardization applying to the earlier all-steel structures marketed, are of less importance when mill construction, masonry, and reinforced concrete are utilized, or changes effected in stock design. It may be more economical to ship materials directly from points of origin than from stock, and fabrication in advance is not feasible, except with steel. No advantage is gained in economy and speed of construction under these circumstances. The professional architect or engineer has nothing to sell but his services. As an expert he may impartially develop the most advantageous layout, prepare suitable plans and specifications, proceed to let contracts, and supervise construction with only his client's interests in mind. When he becomes a builder and merchant he no longer represents the client in the purest sense. His interest is divided.

The industrial executive is seldom qualified to estimate values accurately in this field, because of lack of technical knowledge. When he buys a complete building service from one company he may well employ impartial technical counsel in analyzing quotations, adequacy of designs, and completeness of plans and specifications. Should such an offer prove acceptable, it is desirable that the owner appoint a capable construction man to check the details of construction as they proceed.

Analysis for the Design of an Industrial Plant.—

1. The product
   - (a) Article or articles
   - (b) Quantity
   - (c) Production analysis
2. Plant layout
   - (a) Floor plans and department arrangement
   - (b) Machine and equipment locations
   - (c) Shop transportation system
3. Buildings
   - (a) Number of buildings and type
   - (b) Materials used in construction
   - (c) Material markets
4. Administration
   - (a) Office layout and location
   - (b) Clerical staff locations in plant
   - (c) Entrances and exits. etc.

5. Employees
   (a) Personnel department
   (b) Hospital, rest and recreation facilities
   (c) Cafeteria service
   (d) Club activities
   (e) Athletics
6. Power
   (a) Source and kind
   (b) Distribution and availability
7. Heating, lighting, air conditioning, and sanitation
8. Transportation
9. Fire protection
10. Water service
11. Sewers
12. Site and surroundings
13. General information
14. Consideration of preliminary plans and estimates
    (a) Revisions and adjustments
    (b) Study to determine whether proposed plans are justified considering the cost in relation to the business
    (c) If necessary modify program, but so as to permit ultimate development along ideal lines
15. Final determinations and action

TYPES OF CONSTRUCTION CONTRACTS

In considering the choice of a building contract it is well to remember that "Everything has its price; and if that price is not paid, not that thing but something else is obtained." Morton C. Tuttle, president of the Morton C. Tuttle Company, also points out that the owner must determine the requirement of his project. "Thus, the paramount requirement of one project will be low price; of another, speedy completion; of yet another, the highest possible quality of materials and craftsmanship." [3] Depending upon these and other factors, the arrangements for construction service may take the form of contracts on a (1) lump sum, (2) percentage, or (3) cost plus basis.

Lump Sum Contracts.—As a basis for receiving lump sum contracts, definite plans and specifications are prepared covering the work to be done. It will be appreciated that the interests of owner and con-

[3] "The Choice of a Building Contract," by Morton C. Tuttle, monograph issued by the Morton C. Tuttle Company, Boston, Mass., p. 4.

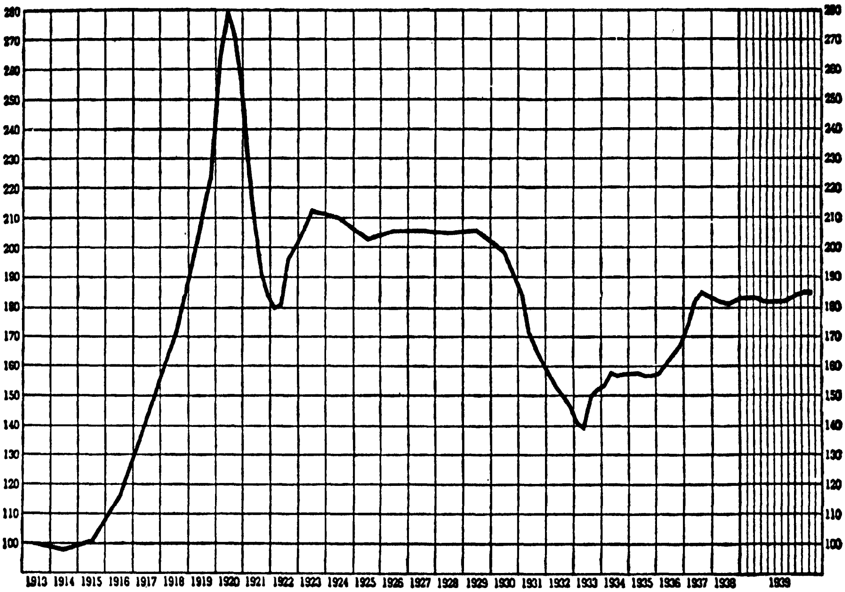
tractor diverge immediately upon the signing of the contract. The owner desires and expects the completion of the contract as he understands it for the price stipulated and in the time set. The contractor must depend for his profit upon his ability to accomplish this result under conditions which arise during the progress of the work. If he is subjected by the supervising architect or engineer to requirements he did not foresee, or encounters difficulties not apparent when he assumed responsibility for the completion of the work, his chances for realizing a profit are imperiled. Under such circumstances there may be a tendency to slight the work and demand high prices for extras.

Notwithstanding its defects this form of contract is used in the majority of cases. Many of its disadvantages are obviated by the preparation of adequate and complete plans and specifications, provision for clear understanding as to conditions of performance, competent and impartial supervision of construction, and selection of capable and reliable contractors.

Percentage Contracts.—Under this form of contract the contractor agrees to complete the work according to plans and specifications. The owner agrees to reimburse him for the cost of doing this and pay him a fee for the service rendered, amounting to a certain percentage of the cost. In almost all cases an estimate is prepared before the work starts which it is believed represents about what the cost will be. In some instances the contractor is required to guarantee that the cost will not exceed a certain amount, and he may share in the savings effected below estimated costs. If plans have not been fully completed before the job is started the owner may not appreciate the probable cost, and because of the uncertainty of plans the work may cost more than it should. Hesitation or delay in pushing a job to completion adds to the cost out of all proportion to the work accomplished. It may be contended that there is not the same incentive to bargain for materials and hold labor payrolls to a minimum in connection with such jobs.

When the work is of such a nature that it is difficult to prepare accurate estimates, or where abnormal conditions prevail in material and labor markets, this form of contract may be advantageous. Its use implies faith in a contractor's ability and honesty.

Cost-Plus Contracts.—With the payment of a fixed fee to the contractor for a specified service, payment for prearranged items, such as equipment rentals, allowances for depreciation, etc., plus the cost of the work complete, many of the evils of the percentage form of contract are eliminated. With this arrangement the contractor is on the same basis as an attorney, physician, or other professional man. For his ability in his



	1926	1933	1938	Sept. 1939	Oct. 1939	Nov. 1939
NATIONAL AVERAGE (30 Cities)	206	146	182	184	185	185
TWENTY-TWO TYPICAL CITIES						
Boston	210	159	190	190	191	191
New York	217	161	192	195	196	196
Buffalo	205	146	185	184	185	185
Baltimore	212	154	184	182	183	183
Philadelphia	214	153	178	182	185	185
Pittsburgh	222	156	199	199	201	201
Cincinnati	208	147	192	193	194	194
Cleveland	222	147	191	191	192	192
Chicago	209	152	190	190	190	190
Indianapolis	209	148	189	190	191	191
Detroit	213	143	189	190	193	193
Milwaukee	207	137	193	193	194	194
Minneapolis	187	143	186	187	188	188
Kansas City	204	144	187	186	187	187
St. Louis	215	151	186	185	188	188
Atlanta	200	138	169	171	173	173
Dallas	195	136	157	159	160	160
New Orleans	207	138	175	181	183	183
Denver	193	138	178	180	181	181
Seattle	189	133	179	183	185	185
San Francisco	179	135	164	171	173	173
Los Angeles	188	132	156	156	158	158

(Courtesy American Appraisal Co.)

Figure 21. Graph Showing Fluctuations in Building Construction Costs in the United States

line of work he is paid a certain sum for accomplishing a definite result. Pride in achievement and consideration of his business future will cause him to give his best efforts to the task. However, he does not have a loss to suffer in event of failure as in the lump sum contract. This form of contract is frequently used when conditions of performance are uncertain or variable, or when speed in beginning and completing the work is urgent. The results obtained under this arrangement will vary directly with the ability and integrity of the contractor, providing he is not hindered by the owner.

The Time to Build.—There is a proper time to spend money for expansion of plant facilities, or to build a new plant. Reference to Figure 21 will show that building costs vary greatly.

Expenditures for physical equipment during a period of high prices impose permanent interest charges not ordinarily warranted by profits in normal times. Unless the anticipated immediate profits will more than equal the abnormal cost of providing facilities a concern may profit more by foregoing additional business until construction costs are lower. Severe losses have been incurred by firms building plants at peak prices.

Lease or Purchase of Manufacturing Plants.—The advantages of leasing may be summarized as follows:

1. Minimizes necessary investment in fixed assets.
2. Permits use of practically all company's capital, except as needed for equipment, in operating costs.
3. Lessens need for bank loans and capital investment.
4. Frees the manufacturer from ownership risks and obligations, such as fire, tornado, or value changes.
5. Depreciation, obsolescence, tax problems are reduced to fixed charges.
6. Postpones building until opportune time when costs are low, or until company requirements are definitely known.

A manufacturer with a satisfactory credit rating can select his site, have a building designed and erected to suit his individual requirements as to size, type of construction, arrangement, and equipment, and lease the completed property for a term of years. The rental cost would probably amount to about 10% or 12% of the investment.

The purchase of an existing plant may prove feasible under certain conditions, as when it is desirable to begin production operations quickly, or advantage can be taken of low values of existing properties. Careful thought, however, should be given to location, necessary repairs and maintenance charges, taxes, insurance, and, above all, to the costs of

operation in the plant. Low purchase price figures are likely to prove misleading in considering all costs over a period of years.

Types of Industrial Buildings.—The enclosure of production equipment and administrative facilities results in buildings of distinct types which may be classified as follows:

1. Single-story buildings.
   (a) Structures with ordinary ceiling heights and column spacing. Special roof construction for additional light and ventilation may be provided.
   (b) Structures designed to secure large unobstructed floor areas. Natural light and ventilation obtained from above by special roof designs.
   (c) Structures with increased height of walls to permit the installation of overhead crane service, to facilitate ventilation, or because of trusses used in obtaining maximum areas of clear floor space. Combinations of structural and equipment features are common to this kind of building.
2. Multi-story buildings.
3. Combinations of multi-story and single-story buildings.

Multi-Story or Single-Story Plants.—Various factors may influence the choice of types for a factory or for individual departmental buildings. Considerations influencing one-story constructions might be as follows:

Low cost of ground area.
Ample room for expansion.
Equipment used unusually heavy or heavy capacity overhead crane service required.
Materials worked upon or products unusually heavy or bulky.
Lighting and ventilation needs.
Hazardous or otherwise objectionable occupancies.
Assembly of heavy or bulky units.
More efficient routing scheme possible.
Time saved in handling materials.
Operating costs may be less.
Greater flexibility with regard to layouts.

Factors suggesting multi-story construction are:

High cost of ground area.
Limited area of site.
Product light in weight and of small bulk.

4. Machinery and equipment light in weight and readily adjusted to usual layouts.
5. Possible better coordination of departments in a vertical plane:
   (a) Reduction in distance between departments or processes
   (b) Utilization of gravity.
6. Economy of construction.
7. Assembly of small units.
8. Ease of expansion, if anticipated.
9. Freedom from street noises, absence of dirt, and in some locations possibility of better lighting and ventilation
10. Opportunity to use top story for departments needing advantages of single-story buildings
11. Natural topography of site.

Multi-story buildings are usually more expensive per square foot on the basis of productive floor area, even though land costs are high. The

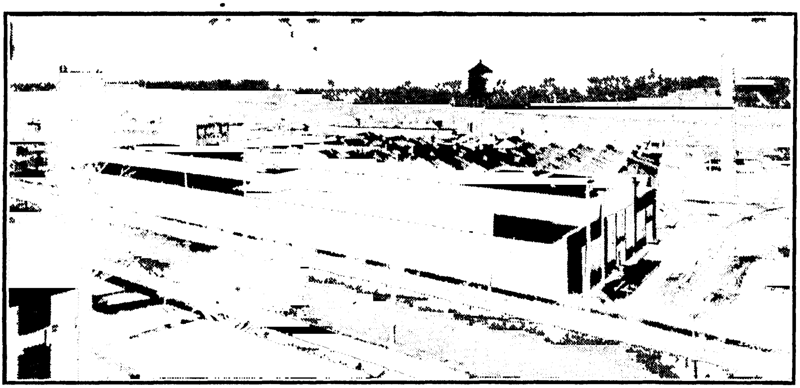


Figure 22. View of Plant of Richards-Wilcox Manufacturing Company, Aurora, Illinois

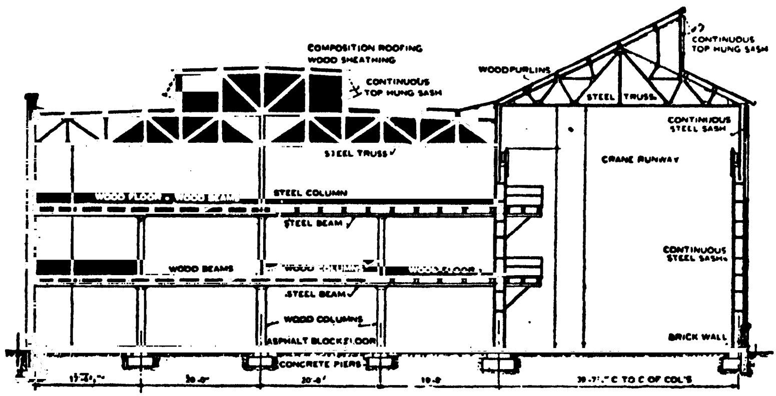
proportion of roof and foundation areas to floor space, necessary story heights, cost of ground areas, and space occupied by stairways, elevators, enclosing walls, and columns all must be considered. A single-story structure may require two acres of ground and provide a usable working area of about 96%, as compared with a multi-story building occupying one-half an acre having a usable area of 82%.[4] With the trend toward decentralized production and the use of medium-size and small plants, more single-story plants are being built.

Figure 22 shows two types of single-story construction. In the foreground the monitor over a wide center bay provides light and air and

[4] Booklet, "Multi-Story or Single-Story—Which?" The Austin Company, Cleveland.

houses traveling cranes serving the entire length of the structure. In the background ordinary sawtooth construction houses machine departments requiring good light, but where ventilation or clear floor space is not an influencing factor. Foundries provide examples of type 1(c), of which Figure 91, page 279, is a good illustration.

Typical one-story plants are those for foundries, car works, steel mills, machine shops, and forge shops in the metal trades industry. Type 1(a) buildings may be used to advantage by many small or moderate-sized manufacturing establishments influenced by low ground costs and possible economies of building construction. The assembly of heavy or bulky products may be carried on to advantage in type 1(b) structures.



(Courtesy of The Austin Co.)

Figure 23. Combination of Multi-Story and Single-Story Building

Typical multi-story plants are those for machine tools, small arms, clothing, boots and shoes, foodstuffs, musical instruments, hosiery mills, furniture, medicines, books, and light assembly work. A study of the factors suggesting multi-story construction will probably furnish economic reasons for the housing of particular businesses in this type of building.

Combinations of the two types are found for one establishment in many cases. Multi-story buildings are arranged in units spaced to permit lighting and ventilating and provide outlooks for the employees. The intervening areas are then roofed at the second floor level, largely with glass in the form of A-frames for ventilation and maximum lighting. With the omission of division walls in the first story the entire area may be utilized, combining the merits of both types of construction. The economic manufacture of small parts may be carried on in the multi-story sections. On the ground floor assembly and erection floors for heavier

units may be laid out, heavy stocks and stores warehoused, and heavy machines, such as punch presses, operated. Expansion of such facilities, if preplanned, is readily possible.

Figure 23 shows a rather unusual combination of this kind. Three manufacturing floors contribute their products to an assembly floor. The traveling crane is used to bring in raw materials, take away finished product, and serve the assembly floor.

CHAPTER 10

CONSTRUCTION OF THE FACTORY BUILDING

Choice of Materials and Type of Structure.—The initial choice of material and type of building for a factory involves both immediate and long-time considerations. Such things as construction advantages, comparative building costs, adaptability to production layout, and capital investment are of immediate concern, while depreciation and maintenance charges, obsolescence, flexibility of design, insurance rates, and fire hazard involve long-time consideration. It is essential also to bear in mind the direct effect of the building on costs of production, its suitability as a healthful, efficient, and pleasant place in which to work, and its advertising value. The lowest ultimate production costs result when direct operating costs combined with overhead charges on buildings and equipment are lowest.

Single-story buildings may be built more rapidly than others. A lengthened construction period results in increased interest charges on the investment, and delays profits from operation. Ordinarily, flat slab concrete designs are more expensive than mill construction. Steel framing, fireproofed, is more expensive than flat slab concrete designs. Construction costs, however, vary with the time and place, being dependent upon local material prices, wage scales, labor efficiency, contracting skill, amount and keenness of competition, completeness of plans and specifications, and weather conditions.

Depreciation and Obsolescence.—Maintenance includes those repairs and replacements, painting and cleaning required to keep a building in good condition. Like a machine, however, a building gradually wears out regardless of any amount of maintenance, and this inevitable loss in value is termed depreciation. It also becomes obsolete. Changes of this character vary with the design, kinds of material used, the quality of the construction, and use to which the building is placed. Depreciation costs on first-class construction may be limited to 2½% or 3% where use conditions are favorable. Obsolescence costs are likely to be much greater. It is now the accounting practice in some industries to recoup building investment costs in from 10 to 20 years as a safeguard against obsolescence.

Insurance Costs.—Insurance costs tend to vary with the risk, and this is influenced by the structure of the building and occupancy. Other

factors are the fire protection afforded by the company and by the community. Other things being equal, insurance rates on both building and contents will be lower in the case of a fireproof structure as compared with one not fireproof. However, rates on an approved design of mill construction with non-hazardous occupancy protected by a sprinkler system will be less than an unsprinklered risk in concrete or steel. The fire loss on unsprinklered buildings as compared to those with sprinkler systems is in the ratio of about eighteen to one. The indirect loss must also be reckoned, as it involves interruptions to business, delay in filling customer orders, and fixed costs.

Flexibility of Design.—A building should be adaptable to changing manufacturing layouts due to progress made in methods and processes, style changes, or altered designs. Suitability for other uses must also be considered, for in negotiating loans bankers may require that values represent approximate market values rather than original or replacement costs. Materials used must withstand deterioration from operating conditions, from such causes as acids in chemical plants, alkalis, condensation in dye rooms of hosiery plants, and high temperatures combined with humidity. Examples of successful efforts in this direction are provided by experience in the Clearing Industrial District, Chicago. They report a surgical supply house now utilizes a building formerly occupied in sequence by a radio firm and a railroad supply company. A company which makes oil mops now uses a structure provided originally for a can company. In other instances a paper firm succeeded one producing fruit drinks; a maker of wax wrapping papers, a motor company, a sausage and meat casing manufacturer, a steel window plant. It should be remembered, however, that flexibility does not come before efficient layout. To keep production costs down the building should be designed for the use to which it will be put.

Types of Construction.—A classification of industrial construction according to materials used is as follows:

1. Mill construction.
2. Steel frame construction.
3. Reinforced concrete construction.

Modern industrial design is more and more including combinations of these types of construction in the buildings for one establishment, and even in individual buildings. Suitability and economy are the tests applied.

Mill Construction.—"The term mill construction is given to that type of building in which the interior framing and floors are of timber,

arranged in heavy solid masses and smooth flat surfaces, so as to expose the least number of corners and to avoid concealed spaces which may not be reached readily in case of fire."[1] The "Building Code Recommended by The National Board of Fire Underwriters"[2] adds many details to this general specification which serve to define clearly accepted and desirable design, and to eliminate unnecessary fire hazard.

The exterior walls of buildings of this type are usually of brick, but may be concrete pilaster design. When of the former type, the area which can be used for windows is less. When of the latter, the floor loads are carried to the pilasters by the cross girders as shown in Figure 24 and the load is transmitted directly downward to their footings, permitting the space between pilasters to be used for windows.

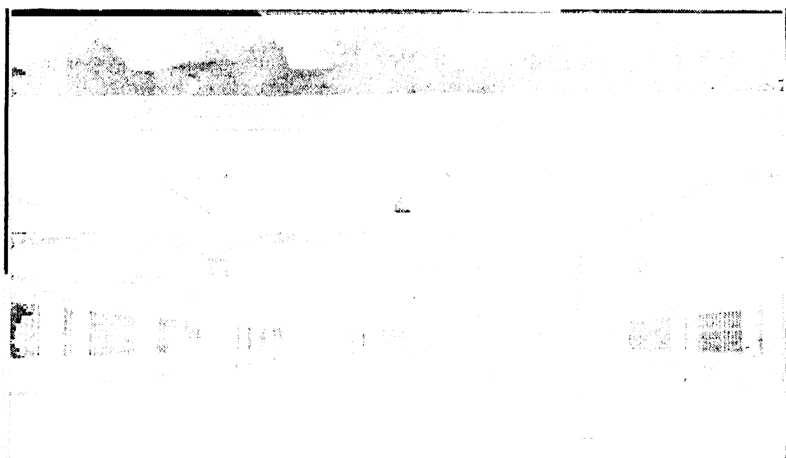


Figure 24. Example of Semi-Mill Construction—Exterior Walls of Pilaster Design

Occupancies and Floor Loads.—Ordinary manufacturing operations may be housed in mill construction buildings, although many prefer a type of structure that gives a more modern appearance. This construction is suitable for jobbing houses, warehouses, and buildings used for the storage of merchandise. It is not suitable for buildings of a height which cannot be reached by water in case of fire, nor for hazardous occupancies. When heavy loads are to be carried, as in storage buildings, the need for short spans and many columns is not a handicap. With many manufacturing operations heavy floor loading is not a factor, and column

[1] Bulletin, Series E-1a, National Timber Manufacturers' Association.
[2] Fourth edition, revised reprint.

spacing may approximate that of other forms of construction. Customary floor design for manufacturing use provides for loads of 100 to 175 pounds per square foot. Column spacing of from 16 to 22 feet may be economically obtained with these loads. For heavy warehouse loads of 200 to 250 pounds per square foot, column spacing of 12 to 16 feet is easily possible and satisfactory in mill construction.

Steel Frame Construction.—Steel construction is economical for use in buildings carrying heavy loads on long floor spans, or for tall buildings having relatively light floor loads. It is especially suitable for truss designs and elaborate and intricate framework, as in cranes, towers, and combinations of structural and equipment features. The material

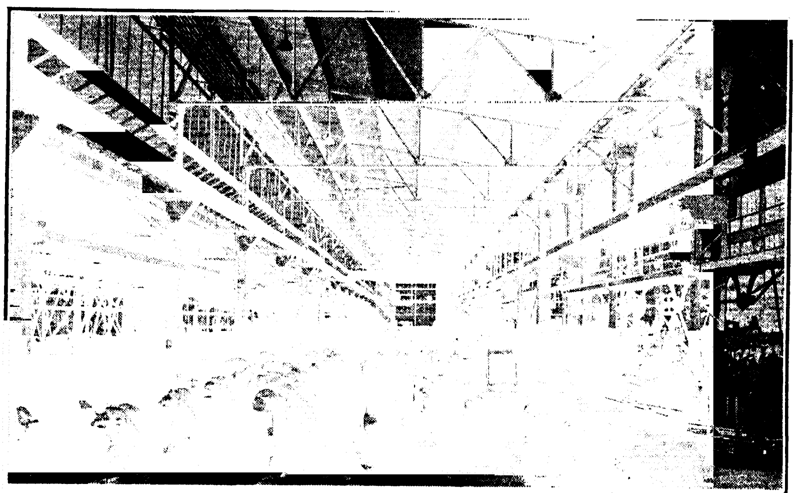


Figure 25. View of the Machine Shop, Consolidated Press Company, Hastings, Michigan

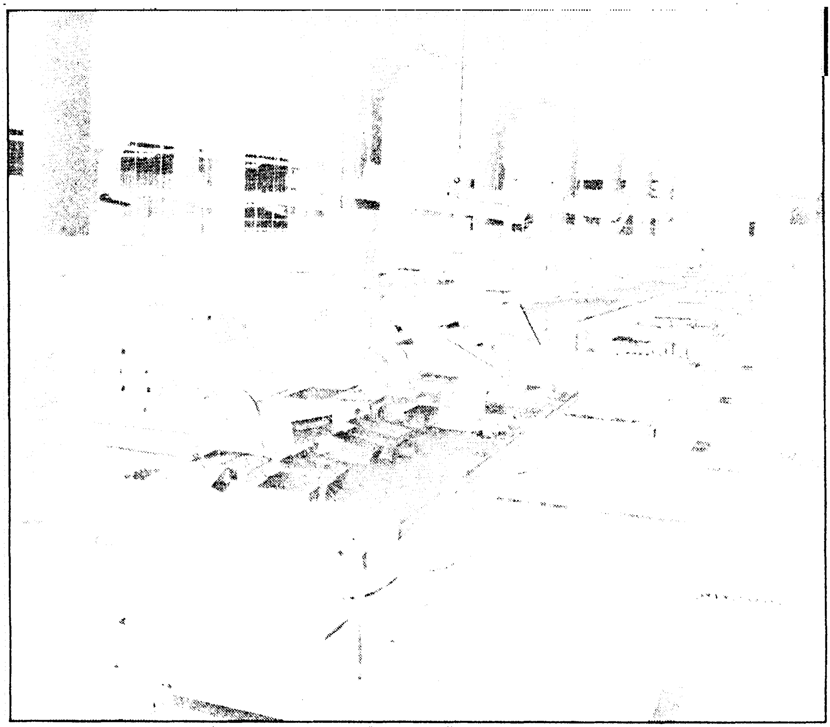
may be fabricated in advance at a distance ready for rapid erection at the site. It will generally be used for carrying very heavy loads, for irregular constructions, and for one-story plants requiring crane service and clear floor spaces. One hundred foot spans are economically possible. Supporting columns for trusses and craneways serve also as roof supports with but slight additions in structural material. The use of steel permits exterior wall and roof surfaces to be of glass to the extent desired. Figure 25 provides an excellent example of the use of steel for a machine shop. Its flexibility in use is attested by the light cross-sectional areas of material used in the trusses as contrasted with that in

the lower columns and the variety of sizes and shapes of rolled sections combined in structural parts.

The choice between fireproofed steel construction and reinforced concrete for multi-story structures carrying moderate loads and of regular design will be influenced by local costs and preference, rather than by any differences in merit of materials. When used for manufacturing purposes steel is most frequently found in other than multi-story buildings, unless they are of irregular construction. A steel frame structure is self-supporting, and enclosing curtain walls are carried at each floor level by the steel frame.

Structural steel is durable if properly painted and protected. Where the nature of the occupancy creates a fire hazard or there is danger from adjoining buildings, enclosing steel columns and beams with concrete or masonry is advisable.

Reinforced Concrete Construction.—Reinforced concrete is widely used for multi-story industrial buildings, warehouses, foundations, ele-



(Courtesy General Electric Vapor Lamp Co.)

Figure 26. Example of Flat Slab Construction

vators, tanks, and storage bins. It provides a strong, rigid and permanent building material practically immune to fire hazard. Depreciation of concrete structures is almost negligible, and maintenance costs are low.

For buildings higher than from four to six stories it is more economical to support the various floors at the outside wall line by columns, and enclose the buildings with light "curtain" walls supported by each floor. For buildings of lesser height bearing walls in lieu of columns may be cheaper. However, consideration of future expansion outward or upward, or desired maximum window areas, frequently suggests skeleton construction even for buildings of three or four stories.

In this type of construction the mixture composed of cement, sand, and concrete is "poured" into forms in a semi-liquid mass. Steel rods have previously been placed in the forms as called for by the engineering requirements, and the concrete surrounds and embeds the steel, forming a composite mass as the concrete sets or hardens. In general the concrete material takes compression stresses, and the steel rods take the tensile stresses. In columns the steel vertical rods help somewhat to increase compression loads.[3]

Flat slab, and beam and girder designs constitute the two principal types of reinforced concrete construction. (See Figure 26.)

Flat Slab Designs.—Flat slab designs are not economical when light floor loads are to be carried but are usually chosen where the loads are heavy. They offer several advantages from an operating standpoint. Windows may be extended to the ceiling level where glass areas are of most value, and the flat ceiling reflects the light well into the interior. The absence of beams and girders permits operating equipment, such as shafting and motors, to be placed nearer to the ceiling, which permits minimum story height. Sprinkler systems will operate effectively with fewer heads. Inserts placed in the slab at the time it is poured facilitate changes in the arrangement and placing of overhead shafting and equipment supports.

Slab thicknesses and spacing of columns will vary with the load to be supported, but loads of 100 to 175 pounds per square foot permit columns to be spaced from 18 to 22 feet apart, economically. For loads of 300 to 500 pounds, spacing 16 to 18 feet is preferable. For storage purposes, where the capacity of the floors is from 200 to 300 pounds per square

[3] An ordinary mix for concrete in building work is one part cement, two parts sand, and four parts gravel or crushed rock. Concrete in compression is designed to carry working loads of from 650 to 850 pounds per square inch; steel, 16,000 to 18,000 pounds per square inch in both compression and tension. Each material is used with a factor of safety of about four; that is, failure would not occur until four times the working load had been imposed.

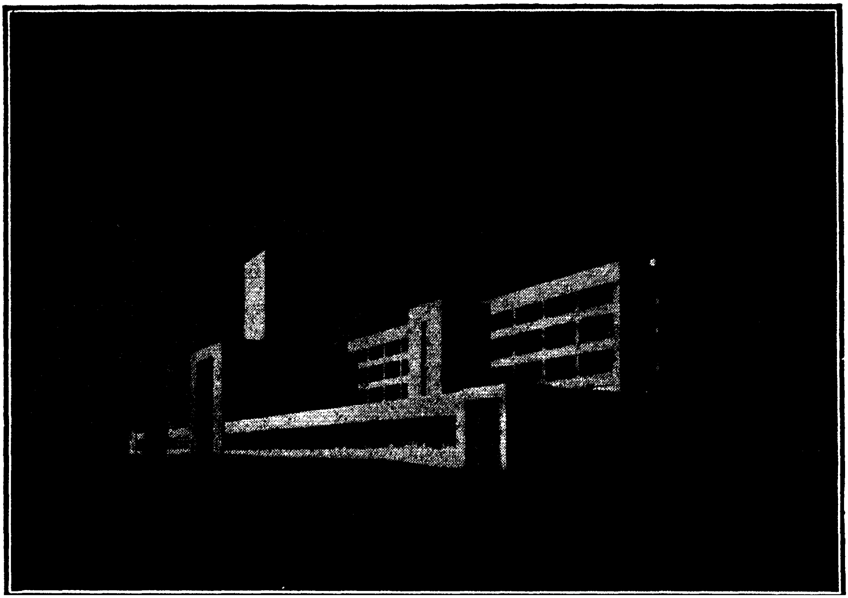


Figure 27. Branch Factory of Burroughs Adding Machine Company, Plymouth, Michigan

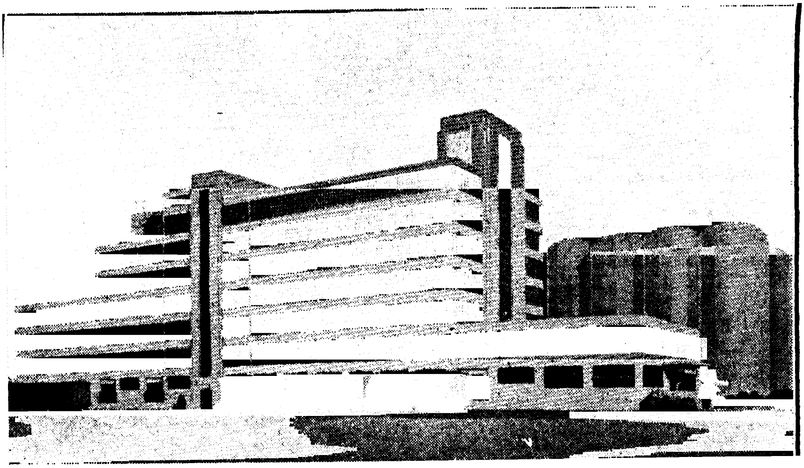
Multi-story section of reinforced concrete, flat slab design. Exterior walls of brick.

foot, and the column spacing from 18 to 20 feet, concrete is as cheap as timber construction in the Middle West.

Beam and Girder Designs.—Beam and girder design may be varied considerably. It may approximate semi-mill timber design with its girders, intermediate floor beams and overlaying floor slab, where the loads to be supported are heavy.

For light floor loads tile and concrete joist construction with either one-way or two-way reinforcement is more typical. In lieu of clay tile or gypsum block, metal pans inverted, or even wooden forms may be used. These light materials serve as a filler between the structural reinforced concrete sections.

Reinforced concrete construction lends itself to modern designs as indicated by Figure 27. See also Figure 28. Glass window areas of 80% to 85% of wall areas are obtainable. In multi-story buildings by extending the floor beyond the columns, window areas may be increased to nearly 100% of wall areas. The glass area near floor levels does not contribute much light to work benches, but may add considerably in lighting inclined or vertical working planes, as in the case of looms.



(Courtesy of The H. K. Ferguson Co.)

Figure 28. A Modern Factory for the General Foods Corporation

The regularity of construction in the typical skeleton type concrete multi-story building makes it adaptable for a variety of uses and its market value remains high. With foresight in planning additions may be added and production increased in a logical manner by prearranged expansion of departments along normal lines.

Factory Floors.—Some of the requisites of an ideal factory floor are: (1) comfort, (2) durability, (3) suitability, (4) economy in first cost, and (5) simple and inexpensive maintenance. Excessive wear necessitates repairs; dusting is harmful to machinery and possibly to materials; absorption destroys the strength of the floor; and swelling or shrinkage forms cracks, affects machinery alignment, and causes unevenness in the surface.

The structural or sub-floor may be equally important from a production standpoint where attached machinery and equipment need to be rearranged frequently, or changed production requirements necessitate new openings, large or small, through the floor. Style changes may necessitate new layouts of production equipment, as in shoe plants. Chemical factories, paint and varnish works, and establishments generally which seek to coordinate departments on a vertical plane, find that readjustments require changes in floor openings, or new ones by the score or hundred in the case of piping layouts. Foresight in preplanning may obviate difficulties in these respects to an extent. Table 2 compares the merits of a number of flooring materials. Steel gratings are used

where air circulation through floors is desired, to permit the passage of dust or dirt, or drainage of water. Steel plates with nonslip surface designs provide a wearproof surface easy to truck over, and which is immune to heat, oils, acids, and abrasion.

Wood blocks, 3½ x 5½ inches, of vertical grain oak, yellow pine, and redwood are in wide general use for floors. They are durable, withstand trucking and abrasion, are easily and economically repaired, and have all the advantages of wood floors. The oak and yellow pine blocks may be impregnated with oil or creosote, but redwood has a natural preservative

TABLE 2. COMPARISON OF FLOORING MATERIALS *

	Industrial Flooring†	Paving Brick	Concrete	Maple	Oak	Pine
1. Acid resistance	100	100	50	30	33	30
2. Alkali resistance	100	100	70	90	90	80
3. Durability	75	100	90	50	50	40
4. Elasticity	60	5	1	90	90	80
5. Fire resistance	75	100	100	0	0	0
6. Nonabrasion	95	30	10	95	95	88
7. Nonslip	100	30	70	50	50	60
8. Quietness	75	5	5	50	50	60
9. Resilience	90	4	1	90	90	90
10. Sanitary	70	50	40	35	35	0
11. Thermal insulation	60	0	5	90	90	90
12. Waterproof	100	10	60	25	25	25

* From advertising material of Johns Manville Co., Inc., New York.
† A mastic type of asphalt floor designed and sold by Johns-Manville Co., Inc.

which makes this treatment unnecessary. The latter blocks are frequently used in food product plants where odors from oil or creosote would be objectionable. The blocks are laid over concrete by first applying a coating of pitch into which they are shoved tight against each other. To facilitate laying over structural wood floors where the surface is slightly uneven, the blocks may be obtained doweled into wood strips in lengths up to several feet. If desired, wood block floors may be given a varnish or wax finish.

Materials Used for Walls.—Brick or concrete masonry for exterior wall surfaces provides adequately for appearance and fire protection. Steel frames and sash with wire glass are an effective safeguard against the ingress of fire. Steel shutters which close automatically in case of fire may also be provided for exterior openings. Walls extended two or three feet above the roof level keep fire away from the roof surface. Tar

and gravel roofs thus protected are fire resistant due to the coating of gravel which protects the layers of pitch and felt underneath.

Recent innovations in factory construction include air conditioning and the elimination of windows. The development of glass blocks provides a material which can be used for both exterior and interior walls which carry little load other than their own weight. The blocks are translucent, admitting from 70% to 85% or more of daylight without glare, depending upon the prismatic pattern impressed upon the face of the blocks. A partial vacuum of dry rarefied air prevents condensation inside the blocks, and a wall 3⅞ inches thick has an insulating value approximately equal to a masonry wall one foot thick. Walls of glass blocks are easy to clean, maintenance costs are low, they are fire resistant, and comparable in first cost with other types of wall construction.[4]

Corrugated sheets of an asbestos-cement composition are available for roofing and siding of skeleton frame structures. They are strong, immune to fire and weather, and do not require painting. Corrugated, rust-resisting metal sheets are used similarly. A recent development has been a steel corrugated sheet coated both sides at the factory with asphalt and asphalt-impregnated asbestos felt which provides protection against corrosive influences. These products do not provide much insulation against heat or cold.

Factory Roof Construction.—With the advent of sawtooth roof construction it became possible to daylight floor areas of one-story structures irrespective of size. The development of the supersawtooth, permitting spans of 75 feet without columns, aided greatly in securing effective production layouts. With this design clear floor areas of 3,000 square feet may be had, as compared with 600 square feet with the ordinary sawtooth.

As large floor areas under sawtooth roof construction are not readily ventilated by natural air movements, operating or weather conditions may necessitate special provision in the way of chimney ventilators, exhaust fans in the walls, or the supply of conditioned air through a duct system. For such work areas, accordingly, monitors, or A-frames and M-shaped roof trusses are often preferable. The latter are very generally found in the metal trades industry in foundries, forge shops, and machine shops. With them good ventilation as well as good lighting may be accomplished for unlimited floor areas of single story structures. Figure 91, page 279, shows an exterior view of a modern foundry with this type of roof construction. There is little difficulty in effecting advantageous production layouts and departmental arrangements, inasmuch as only a

[4] From a pamphlet issued by Owens-Illinois Glass Company, Toledo, Ohio.

few columns are needed to support the roof, and the benefits of good lighting and ventilation are obvious.

Experience has prompted industrial executives, moreover, to have the top floors of multi-story buildings designed with special roofs. In nearly every plant there are some processes or inspection operations which will benefit by improvement of working conditions, or by better layouts possible with unobstructed floor space. Sawtooths, monitors, A-frames, or M-shaped roof trusses are usually possible. Interior floor space otherwise not effectively used is made the most valuable. The expense of special constructions of this nature is not prohibitive.

Architectural Design.—The architectural design of an industrial plant is of secondary importance to the practical planning of the structure from the production standpoint. The primary function and purpose of such a building is to aid in producing goods economically. However, workmen are sensible to attractive workplaces, and it is recognized that pleasing and comfortable surroundings have a distinct effect upon men's interest in their work, upon their craftsmanship and plant spirit, and thus become tangible factors affecting production costs.

Aside from these considerations the advertising value of factories is considerable. Thousands of people may pass a plant annually, and by means of advertising many more may come to associate a product with its "home." As a consequence, manufacturers seek to have establishments which will bring prestige to their products, and of sufficient interest to attract attention. As the added cost for an attractive plant is only a matter of 1% or 2% of the cost of the building, the expenditure is invariably justified simply as a matter of good business. Figure 28 pictures a plant for the General Foods Corporation. It provides an excellent example of modern, utilitarian, and attractive design.

CHAPTER 11

POWER AND HEATING

Management Control of Power and Heating.—Providing for power and heating facilities, and making arrangements for the distribution and utilization of their products, call for business and operating intelligence as well as engineering skill and experience. Power plant operation is distinctly a technical field, but precisely for this reason it needs management control. The power plant, like any other service department, must be built and operated with respect to the industrial plant as a whole. It must take its place as a supplier of power and heat for the operations of the plant and for employee comfort with the outlay of capital and equipment best adapted to the particular purposes. Here as elsewhere it is up to the management to see that the long-run company policy is carried out in power plant operation.

A good organization to handle major power plant and heating problems consists of the executive responsible, the plant engineer, and a reliable firm of consulting engineers with a successful record of industrial power plant experience. The executive is thoroughly capable of thinking through and evaluating the reports and recommendations of these staff assistants. He will bring to bear on the problem a business sense and vision of the future, which is highly desirable. The plant engineer will have an intimate knowledge of plant power and process equipment. The engineering consultants, specialists in industrial power problems, contribute a knowledge of the latest developments and a breadth of experience. They will advise with regard to designs and equipment most suitable for the service required, and embody conclusions in drawings and specifications. In large organizations, the staff of the operating executive responsible for power service often combines the talents of the three groups mentioned, and may successfully cope with all problems that arise.[1]

Engineering Design.—An industrial power plant is not an end in itself. A power plant may be ideal, technically considered, and with low operating costs, and may yet result in high power costs because of the

[1] The executive in charge will probably be an engineer who has graduated into executive work. The combined intelligence of his staff may equal or exceed that of consulting firms.

investment required. For this reason many refinements of central station design are not applicable, profitably, to the average private plant.[2] Further, complicated operating equipment which functions satisfactorily in the hands of skilled central station attendants may be the cause of costly interruptions to service when handled by those less skilled. Private plants, to be reliable in operation, must frequently be of simple, even "foolproof" design. The increased cost of operation this policy suggests is of minor importance compared to the assurance of continuous service.

Function of a Power Plant.—The function of a power plant is to produce energy for operating machinery, to provide heat, light, ventilation, refrigeration, compressed air, steam and hot water for processes, or to pump water for drinking purposes, fire protection, or process needs. Furnishing power to operate production machinery may be a minor function of a power plant, or it may be a by-product of other services rendered.

Central Station Power Versus Isolated Plant Power.—There is an unmistakable trend toward the purchase of power, as evidenced by the rapid development of power distribution systems in many states. In Illinois, alone, over 7,000 miles of transmission lines serving 1,200 communities are already constructed. Few industrial localities are without central station service, which to a rapidly increasing extent implies superpower service. The term "superpower" indicates the interconnection of power lines to insure continuity of service to all customers, even though one or more stations in the chain become temporarily disabled. The merging of 6,500 generating and distributing systems into 3,500 networks has added to dependability of service. Of these, some 215 systems produce and distribute 93% of the electricity sold.

Advantages of Central Stations.—Central stations continue to make rapid progress in manufacturing power cheaply. As they operate on a large scale, they can utilize talent, equipment, and operating refinements not available, economically, to the isolated plant. Obsolescence is a lesser factor in costs. As compared with a group of isolated small plants, less generating capacity is needed in the central station due in part to the demand for power, and in part due to the lesser need for reserve equipment. When central stations are interconnected, those of less efficiency may be kept idle except during periods of maximum demand, and each

[2] A central station plant is defined as one which serves plants under different ownership. A private plant is one which produces power for one or more local industrial establishments, all under a single ownership.

individual plant utilized to best advantage. Where hydro-electric plants are included in a group with steam plants, the latter may be used to supplement and augment the variable power output of the former as occasioned by seasonal differences or varying rainfall on the respective watersheds. A relatively high load factor[3] cuts down the overhead cost per unit of output, a big item in power cost. A handicap of central stations, ordinarily, is inability to utilize the heat losses from engine or turbine operation, which amount to over 50%. When the central station is so situated that it can sell heating service as well as power its advantage is increased.

Reasons for Considering a Private Plant.—Power plants having less than 500-horsepower capacity are seldom economical if central station service is available. Concerns with power bills aggregating $10,000 a month may also find it advantageous to buy rather than make power. Ownership of an existing plant, the production of power as a by-product, inability to secure a proper low rate,[4] or the possible unreliability of central station service[5] are reasons for considering private plant operation. When power alone is to be produced in a power plant, it is generally cheaper to buy than to make it. This would seem to be conclusively proved by the general use of purchased power in the coal industry. Seventy-five per cent of the coal mined in Illinois comes from mines using central station power service for mining operations.

The need for industrial heat, heat for buildings, exhaust steam, hot water, or other power plant service may make power an inexpensive by-product. To determine whether or not power should be purchased, and the advantage to be gained by buying or making it, a careful analysis is necessary in each instance. General rules are not applicable. It may prove feasible to make some power and purchase the balance required. Lower purchase rates are in effect for those hours when the demand is low, and for uniform rather than fluctuating loads. Depending upon circumstances, rates, hours of operation, and considering stand-by costs, a company may purchase a constant amount and generate energy for peak loads, or vice versa. Heating requirements during part of the year may make operation of power-producing equipment economical for that period, and purchased energy economical at other times.

[3] For a definition of "load factor," and a discussion of its significance in power costs, see pages 161–162.

[4] As rate schedules are largely controlled by state commissions, power companies are not free to make individual rates to customers, which sometimes necessitates revision of rate structures to adapt them to changing industrial needs.

[5] Long-distance power lines where steel towers are used, are considered dependable. When power lines in and near cities are run underground, they are immune to line troubles.

Importance of a Cost System.—In considering power costs, in connection with figures submitted by central station representatives seeking power contracts, a number of factors must be considered. Such figures may be misinterpreted from lack of knowledge of what plant power costs really are. A common error is failure to recognize the value and cost of the heat, process steam, hot water, or other plant products, which must continue to be manufactured within the plant even though energy to run machines is purchased. A good cost system will charge the proper departments or processes with these costs, which when deducted from the total costs of operating the power plant will give the true cost of power energy to operate machines. This latter figure may be low. For example, when a factory power plant supplies its own electric current for power, the steam distribution will average 30% to the engine room and the balance to the factory.

Examples of Power as a By-product.—At the South Philadelphia works of the Westinghouse Electric and Manufacturing Company, power is a by-product of heat production during the winter months. In the summer months it is purchased. Furniture and woodworking plants make use of waste for fuel, and also utilize exhaust steam and waste heat in dry kilns, reducing power costs to a minimum. In the textile industry, in bleacheries, dye-houses, and chemical plants, wherever exhaust steam or hot water is used extensively in processes, power is largely a by-product of process needs.

Stand-by Power Costs and Supplementary Service.—A few plants may find it cheaper to generate normal power requirements and to utilize central station service for emergency or peak load demands. This practice, however, is discouraged by utility companies by exacting a minimum fixed charge per month, which may be applied on current purchased at the regular rates. The stand-by charge incurred is the difference in cost between the power so secured and its lesser cost if purchased in larger quantities, or the expense of generating it in a private plant.[6] A more usual arrangement is to purchase a constant quantity sufficient for normal needs, utilizing plant equipment to care for peak loads. In this way low power costs accrue because of the quantity used and the even load curve.

Factors Influencing the Purchase of Power.—Even though the cost of producing power might be low, there would still be a question of the wisdom of investing money in capital equipment of this character.

[6] An Illinois company pays such a fixed minimum charge of $500 per month. The stand-by charge is the extra cost of buying the small quantity of current at ordinary rates, as compared with cost of producing it in large quantities.

Fuel and labor costs are increasing; rapid progress is being made in power plant practice; hence obsolescence is an item that enters into power plant costs. Ready capital may be needed in financing production, or may yield a much higher return if used in the manufacturing end of the business.[a] Again, an industrial power plant may prove a nuisance to the neighborhood. Central station power rates, on the other hand, are stable, and increased efficiencies will likely more than balance higher fuel and labor costs. For these reasons before a firm commits itself to the policy of making its own power, it should be certain that the saving will be considerable.

Power Plant Equipment.—Equipment for power plant operation may be (1) a boiler and reciprocating steam engine or steam turbine, (2) water turbines, (3) Diesel engines, (4) gas and gasoline engines. The relative importance of the prime movers may be estimated from the results of a survey which discloses the kinds and capacities of equipment used in 72 industrial plants. Of the 200,000 horsepower reported hydraulic composes 1%, steam engines 20%, steam turbines 76%, gas engines 1%, and Diesel engines 2%. The use of either the steam engine or the steam turbine requires a boiler installation with its attendant stoker and various devices for increasing efficiency such as superheaters, feed-water heaters, air preheaters, etc. The design of the boiler is primarily influenced by the amount of power required and the type of fuel available and the amount of capital to be invested. The steam turbine is largely replacing the steam engine, due to its compactness, high economy under all loads, the elimination of cylinder condensation, and the small number of moving parts. The turbines have supplanted steam engines almost entirely for central station service. Diesel, gas, and gasoline engines do not, of course, require a boiler. The use of Diesel engines is gradually increasing. For small power requirements and for stand-by equipment, especially when heating is not a by-product, the low-cost, flexibility, and dependability of this type of power is attractive. Gas engines are sometimes used to develop electrical energy when a supply of combustible gas is available. Gasoline engines are used only for light duty and stand-by service.

Electric Current.—Electric current is produced by electric generators operated by one of the prime movers and may be either direct or alternating, depending upon the design of the generating equipment. Either type of current will operate lamps or any process requiring heat alone equally well. Series wound motors can be operated on both alternating and direct current. Other motors are operated on one or the other current depending upon their design.

Alternating current is used in most cases because of the ease with which the voltages may be transformed. A high voltage is generated at the power station and distributed to voltage transformers at the point of use where it is stepped down to a lower voltage. High voltage transmission lines result in a great reduction in line losses and appreciably reduce the heavy investment in cables necessary with low voltage transmission. Motor generator sets must be used to transform the voltage of direct current. These installations are more expensive than transformers and require more attention.

Direct current is necessary when machinery is to be operated at widely varying speeds, as in the case of cranes and of some machines, or when extreme constancy of speed is required for electro-plating and many chemical processes. Some elevators are operated with direct current, others with alternating current, and some with a combination of the two. Induction motors, operated with alternating current, will show a slight speed variation between partial and full load. For minor needs alternating current may be converted into direct current by the use of a rotary converter, instead of operating a separate direct current generator.

With the use of alternating current the elimination of commutators on generators simplifies construction, saves in both first cost and maintenance, and assures greater continuity of service. The usual alternating current motor is essentially a single speed machine, although variable speed types have been developed with limited fields of successful use. The chief advantages of alternating current systems are low distribution costs, and flexibility of voltage changes with transformers.

Load Factor.—The load factor may be defined as a ratio of the average load to the maximum load during a given period. For example, a plant equipped with 4,500 horsepower of motors may operate a maximum of 4,000 horsepower for a half-hour during 8 hours of operation, but provide an average load on the power plant of but 3,000 horsepower. In this case the load factor would be 75% for the 8 hours of operation or 25% for a period of one day of 24 hours. It is apparent that the necessary investment in power generating equipment, always a big factor in power cost, is not fully utilized.

A tendency to overestimate the load factor, and consequently to underestimate unit power costs, is responsible for many errors in properly balancing power plant investment with actual needs. Power and steam demands fluctuate from hour to hour, and shutdowns occur due to lack of orders or interferences with production. Shorter work days and the five-day week lower the load factor, while two-shift or three-shift operation tends to increase it, and to double or triple the use of capital invest-

ment. A plant averaging 2,400 hours per year, with a load factor one-third that of a similar plant operating 7,200 hours per year, does not justify an equal investment in a power plant.

A low load factor suggests the advantage of purchasing power, or at least minimizing the investment in a power plant by the omission of stokers, coal and ash handling machinery, and other refinements, even though operating costs are increased.

Where power and steam demands are combined in one plant, the conditions are modified. Conversely, a high load factor justifies greater perfection of equipment and increased investment.

Power Factor.—With direct current, volts times amperes, or volt-amperes, give the true power. When alternating current is used with induction motors, transformers, and other equipment that operates through an electro-magnetic field it is made up of two components. "The first is power producing current, which is converted by electrical equipment into useful work and registered on the meter as kilowatt-hours. The second is magnetizing current, which cannot be converted into useful work although it is needed for the operation of motors and other kinds of equipment. Power factor is simply the proportion of the power-producing current to the total." [7]

The current component that produces the magnetic field uses up capacity of conductors and other equipment and produces in general the same effects and losses as the working or energy current. Therefore, generators, transformers, and distribution lines may be loaded to full capacity, but only a part, say 60% or 70%, of the total current is doing useful work. Thus, low power factor may represent an unwarranted expense amounting to hundreds or even thousands of dollars a year.[8] An ordinary value of the power factor is from 70% to 85%, but it is sometimes much less. Most utility companies penalize concerns that fail to maintain a high power factor by exacting increasingly higher rates per kilowatt-hour as the power factor drops below 85%.

A low power factor may be corrected in three ways: (1) by the use of synchronous motors, (2) by better selection of motors, and (3) by the use of condensers. Some kinds of electrical equipment tend to neutralize the effects of induction motors on the system, and thus increase the power factor. Placing lights and synchronous motors, which have a power factor of unity, in the same circuit with the low power factor

[7] "Six Ways to Save on Power Bills," by L. D. Cleverly, *Factory Management and Maintenance*, Vol. 97, No. 7, p. 82.

[8] The technical definition of power factor is the ratio of watts of true power to the apparent volt-amperes. A watt is the unit of electrical power; a volt is the unit of electromotive force; an ampere is the unit of measurement for electric current. One volt times one ampere, or volt-ampere, gives one watt of power, theoretically.

equipment will raise the rating of the group. Condensers are expensive, but at times their use may be amply justified to avoid penalty payments on the power bill.

Choice of Motor Drives.—The effective location and arrangement of machines for production is of first importance; the form of drive is secondary. Manufacturing advantages, although less readily reduced to money values, usually outweigh the more apparent fixed costs and power expense of machine operations. The latter seldom exceed 2% or 3% of machine-hour costs. Probably in 50% of the cases the proper choice of drive is clearly indicated, but in the other half the economic solution of the problem is not so apparent. Each form of drive, however, possesses characteristic advantages.

Group Drive.—With group drive one motor is used to drive two or more machines, the power being transmitted by belt to a line or countershaft, and from it by belts to the individual machines. In individual or unit drive each machine has its own motor.

Group drives are considerably cheaper in first cost and in maintenance than individual drives. Breakdowns are less frequent due to use of larger motors, and these are likewise usually more efficient in respect to speed, loading, and power factor. Peak loads on any machine in the group are readily cared for by the reserve power of the large motor. A number of like machines, symmetrically placed, which may be in operation or idle as a unit, suggest group drive: a bank of knitting machines in a hosiery plant, a group of lathes or automatic screw machines operated more or less constantly when the power required to drive each varies considerably, and when occasional extreme peaks are of momentary duration.

A valid objection to overhead belting and shafting arrangements may be overcome in part by suspending this equipment from the ceiling below, with short drive connections through the floor. In single-story plants power equipment placed below the floor in power tunnels is entirely removed from working areas, and made readily accessible for maintenance.

Individual Drive.—When each machine has its own motor, changes in manufacturing arrangements can be made more readily and at less cost than when group drive is used. The elimination of overhead shafting and belting provides for better lighting, air circulation, and fewer hazards; and there is no interference with overhead cranes, conveyors, or other equipment. Individual motors on machine tools permit closer speed adjustment of the tool to the work. During slack seasons or when

only a few machines are in use, it is not necessary to operate idle shafting and belting.

Woodworking departments with unsymmetrical machine arrangements and greater distances between machines provide excellent examples of the use of individual drive. Line production arrangements where flexibility is essential to take care of changing models or styles, and where the demands of adjacent machines are so variable, suggest individual motor equipment. For very heavy work it is more convenient to move machine tools to the job than it is to move the work. Portable machines will naturally be individually driven. Other examples are machines which use considerable power (20 to 30 horsepower or more) and operate at a uniform load, or are in use part time only. A machine in a group using considerably more power than the others may affect their speed or, when idle, give a low motor efficiency. It is best operated independently.

Emphasis has been placed upon the economy of group drive for light machines arranged in rows or banks with small, uniform power requirements. However, some very extensive installations of individual drive for layouts of this kind have been made in the textile and machine industries. The advantages gained are less idle machine time due to breakdowns, accurate power applications, and particularly the elimination of the "jungle" of overhead belting and shafting which interferes with lighting and ventilation and increases the accident hazard. The remarkable contribution made to pleasant and agreeable working conditions in these ways is an important factor, although it must be admitted the cost of power is greater.

Disadvantages of individual drives include greater first cost, higher maintenance charges, and operating costs. "The installation cost of individual drive amounts to from 80% to 200% more than for a corresponding group drive. Total annual cost, including fixed charges, will be around 25% to 50% higher than for group drive. Use of comparatively small motors that usually operate considerably underloaded results in a low plant power factor." [9] The repair cost per motor for individual drives is greater than for group drive, due to the less rugged construction of small motors and greater exposure of locations.

Fractional Drive.—Fractional drive uses two or more motors as the driving force for various elements of the same machine. Many large or complex machines use power at different points for quite different purposes. Suitable motors installed for each separate power-using part

[9] "Avoid Loss in the Mechanical Transmission of Power," by L. S. Morrow, *Factory Management and Maintenance*, Vol. 93, No. 10, p. S-124.

add to power efficiency, and eliminate the need for intermediate mechanisms coordinating the machine parts, which cause lost motion, noise, wear, lost time, and complicated construction. Multiple spindle drill presses, grinder lathes, huge printing presses, and many other complicated machines of modern industry utilize more than one motor.

HEATING

Purposes of Heat in Industry.—An industrial plant has two distinct uses for heat. First, it must provide heat to create comfortable working conditions for the employees, and second, many processes require the application of heat for their completion. Among the many industries dependent upon heat in processing may be mentioned steel, glass, baking, rubber, plastics, and oil refining. In fact, there are few industrial plants that do not employ heat at some point or other in their processes. For the purpose of heating the plant for the comfort of the workers the various systems may be classified according to the heating medium or character of equipment used, such as (1) hot water, (2) steam, (3) unit heaters, and (4) electric heating. Frequently combinations of two or more systems are used in one installation.

Selection and Design of Heating Systems.—A heating system used for several months of the year in cold climates justifies a greater investment with the idea of decreasing operating costs, principally fuel and labor. Refinements in design to conserve the heat supply, lessen labor costs, and increase the efficiency of the fuel used are warranted. A shorter, less severe heating season warrants less cost of plant and permits fuel and labor costs that are relatively higher.

Heating systems may be designed for temperatures 10 to 15 degrees above the official lowest temperature on record for the locality, or the average minimum temperature. Practically all systems so designed are sufficiently flexible to provide adequate heat during the brief periods of colder weather. Severe weather comprises about 5% of the heating season; cold weather and mild weather, about 20% and 75%, respectively.

The capacity of a heating system must be balanced against the demands for heat, or heat losses. In determining what these are for any building or room it is necessary to consider: (1) the loss of heat through the enclosing walls, floors, or roof; (2) air infiltration or leakage; (3) the effect of wind; (4) the need to increase temperatures of materials within the building; (5) the effect of machine operation or processes in increasing temperatures; (6) the necessity, when the building is not heated continuously, of raising inside temperatures to desired levels; (7) in

some instances contamination of the air, requiring the removal of large volumes of heated air which must be replaced.

Heat requirements are readily calculated by heating engineers, using the standard unit of heat measurement as a basis. This is the British Thermal Unit (B.T.U.) which denotes the heat necessary to raise one pound of water from 63 to 64 degrees F. The rates of heat losses for various materials and constructions are well established.

Heat as a By-product of Power.—The need for heat with power suggests the double use of steam, and possible economy of a company-owned, dual-purpose power and heating plant. This is not always true, however. The initial cost of high-pressure steam boilers is greater, and the operating expense much more, than for low-pressure units needed if only heating is to be considered. Under certain conditions purchased power energy is cheaper. It may pay to buy power and make heat only. Some local utility plants which furnish customers with both heat and power find it more economical to produce heat alone, bringing in power from more efficient plants 50 or more miles away. With gas or oil for fuel, or the use of mechanical stokers, the labor attendance for a heating plant may be reduced to incidental attention.

The Purchase of Heat.—Central station heat is not uncommon in urban or industrial centers, and may be obtained from either hot water or steam. In large boiler plants, steam production is on a much more efficient basis than in small plants. Differences of as much as 50% are not unknown. Distribution of steam in most cases is at low pressures (5 to 10 pounds per square inch) but sometimes high-pressure mains (with pressure at 100 pounds per square inch) are used to carry the steam to local distribution centers, where reducing valves are used to feed low-pressure systems, which in turn lead to individual plant mains. Distribution losses should not exceed 10%.

Plants which produce an excess of exhaust steam or hot water are in a position to sell heat to neighboring plants. The gain to the purchaser in these cases is the elimination of the investment needed for a private plant, and perhaps cheaper heat.

General Advantages of Hot-Water Systems.—Gravity hot-water systems cost more than steam systems because of the larger radiators and piping needed. Size differences may amount to 50% or 60%. With forced feed systems the cost may be less than for steam, due to the considerable expense for radiator fittings needed when steam is used. Initial heating with hot water is much slower, but once heated this medium gives off heat for a considerable time. If temperatures above

freezing need to be maintained because of the nature of the contents of a building or to protect a sprinkler system, a hot-water system may be favored.

A great advantage of hot-water heating is the readiness with which the amount of heat given off may be controlled by the engineer in the boiler room, by varying the temperature of the feed water. The mean winter temperature for several northern cities is about 40 degrees. This outdoor temperature requires hot water at a temperature of 145 to 150 degrees to heat buildings properly. For zero degree temperature, the hot-water supply will need to be about 200 degrees. Seldom will it need to be 212 degrees, the minimum temperature for steam systems. From 15% to 20% less fuel is required on this account, and the systems are more simple and inexpensive to operate.

Steam-Heating Systems.—The higher temperatures of steam produce higher radiator temperatures, and hence insure quicker room heating. This permits small radiator and pipe sizes to be used. Steam systems are quiet in operation and provide a more even heat in all the radiators. Low-pressure systems are the rule, which implies not more than 10 pounds of steam pressure, and usually less than 2 pounds.[10] Steam pressures can be varied in accordance with the weather conditions. Where heat is needed for short periods only, when quick heating is desired for warming a building in the mornings in mild climates, or heat is not needed except during working hours, a steam system may be the best, as the plant can be shut down between times.

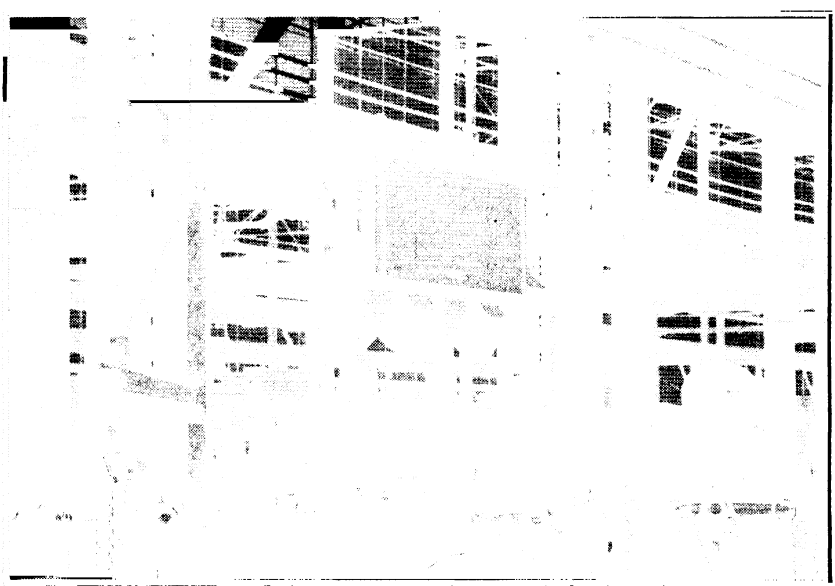
Steam heating is more flexible and more easily controlled at the radiator than hot water. By means of a system of temperature regulation, steam radiators may be controlled individually or by groups. This is done by controlling the amount of steam entering the radiators. Individual steam radiators may also be controlled by use of graduated supply valves on the radiator. This has never been successfully done with a water heating system. In a hot-water heating system the temperature of the water in the system is controlled but there is no control on the individual radiator or heating unit. The principle is the same as controlling steam pressures.

Vacuum Systems.—With a vacuum created in the heating system by the removal of the air and condensate, steam will form at much lower temperatures (at 98 degrees if the vacuum could be perfect) and be pulled through the system, rather than forced through under pressure, as

[10] Steam at a pressure of 10 pounds has a temperature of 240 degrees: at 5 pounds, 228 degrees; at 0 pounds, 212 degrees.

with other systems. The air is exhausted from the system, and the condensate returned by gravity as above described, or a condensation pump or vacuum pump may be utilized to return the condensate to the boiler, and an air pump to exhaust the air from the system. Both pumps may be operated by the same motor. The removal of air makes all heating surfaces more effective. Considerable fuel is saved, as the heating surfaces may be kept at less than 212 degrees during mild weather. Ordinarily, in so-called vacuum systems the pressure is maintained only slightly above or below that of the atmosphere.

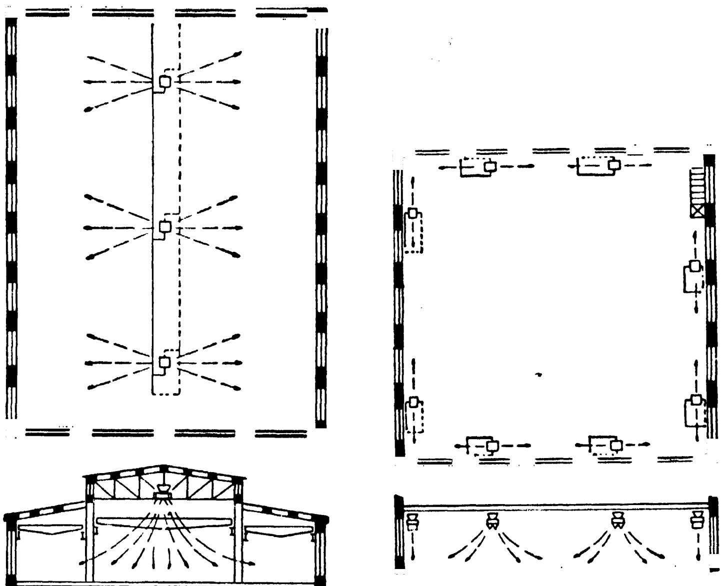
Unit Heaters.—Unit heaters consist of a heating unit, over or through which the air is circulated by a fan, and then delivered to the area to be heated through louvers or discharge ducts. The height, direction, velocity, and temperature of the air currents are subject to control. Steam is the usual source of heat, but hot water, gas, and electricity are also used. Heaters using steam or hot water circulate this heating medium through a radiating element composed of copper tubes with attached fins to facilitate the passage of the heat into the air. A tractor manufacturer uses the fan and radiator unit of one of its tractors as a unit heater and finds it efficient.



(Courtesy of Buffalo Forge Co.)

Figure 29. An Example of a Large Size, Suspended Type Unit Heater

Unit heaters may be either of the floor type or suspended over the heads of the workers. Since they are of varying sizes and capacities, they permit great flexibility in adaptation to the needs of the situation. Figure 30 shows this possibility. The heaters are relatively small, compact, and light in weight. A unit weighing 240 pounds or less equals in heating 700 square feet of direct radiation weighing 4,900 pounds. Installation costs are low because of the simplicity of the piping and the few units required as compared with dozens of radiators with necessary



(a) A monitor type building 80 x 160 feet, over 30 feet high, is heated with three heaters.

(b) An arrangement for a wide area multi-story building having no roof exposure, but with 700 feet of wall space.

Figure 30. Examples of Heating Layouts Using Unit Heaters

(Courtesy of L. J. Wing Mfg. Co.)

valves and traps. Maintenance costs are reduced and depreciation is less. This method of heating has been accepted as standard for large floor areas with high ceilings, and it is being adapted to an increasing extent to smaller room areas and ordinary ceiling heights.

The use of small heaters serves to distribute heat uniformly and to direct the heated air currents toward those points hard to heat with other equipment, such as cold corners, large window areas or entrances, and doorways used for trucking. Overheating of work areas near radiators is also avoided. In these ways the discomfort of the workers is

averted and individual efficiency increased. With other methods of heating there is a wasteful accumulation of heated air overhead. Unit heaters project heated air downward to the working levels, decreasing temperatures in the upper areas, reducing heat losses, and saving heat. In mild weather fewer units may be operated. At night and over week-ends temperatures can be lowered to 35 degrees or less, instead of the usual 40 degrees permissible when direct radiation is used. Normal working temperatures may then be had in from 20 to 40 minutes as compared with one to two hours with direct radiation.

Unit heaters may be provided with an outside air connection and fresh air drawn in and circulated in the proportion desired. This arrangement may be necessary to replace vitiated or contaminated air. The heat may be controlled automatically, using thermostats, or manually by the simple turn of a switch. The rate of movement of the air in working areas is readily controlled and, where desired, may be almost imperceptible. In the summer months unit heaters serve as ventilating equipment in circulating the air supply, and, where outside connections are provided, introducing fresh air.

Electric Heating.—Electricity as a source of heat for industrial buildings is not common, but in some localities low-cost electric energy makes it practicable. Heating may be accomplished by means of electric radiators, but more often the heat energy is transferred to hot-water or steam systems. When electric radiators are used, the current is taken directly to them through wires. An electric switchboard in a small metal cabinet may then constitute the entire heating plant.

When coal is used for fuel, only about one-half the heat units are made available, while the efficiency of heat transfer is 100% for electricity, and costs are independent of the quality of management in the heating plant. Further, investment, maintenance, and operating costs of a boiler plant are eliminated altogether. Space requirements, the factors of depreciation and obsolescence, dust and dirt, and the need for administrative attention should also be considered.

With electric radiators, as used in smaller installations, the amount of heat is closely controlled by thermostats, and the heat energy may be shut off immediately, giving utmost flexibility in use with varying weather conditions. As a supplement to other heating systems it serves well. The ease of supplying heat energy through wires, and the variations possible in number and size of heating elements make it possible to use it in crane cabs, street cars, electric trains, and all sorts of out-of-the-way locations. The heating elements in unit heaters also may be electric if energy rates or local conditions are favorable to costs.

HEAT FOR INDUSTRIAL PROCESSES

Choosing the Heating Element.—Heat for industrial processes is usually obtained by burning coal, oil, or gas, or utilizing electric energy. The latter source of heat is the most expensive per unit of heat energy, yet the most widely used, and often the most economical, all factors considered. The gas utilities, however, have awakened to the potential market for industrial gas in industry, and by perfection of gas-using equipment and development of intelligent, aggressive sales policies have made gas a real competitor of other heat sources for a widening range of uses.

In choosing a source of heat supply, factors to consider are as follows:

1. Fuel costs, including storage and handling charges, the hazard involved, dependability, etc.
2. Necessary investment in heating equipment, auxiliary devices, installation costs, and the space requirements.
3. Operating costs: (a) fixed costs, such as interest, taxes, insurance, depreciation, and obsolescence; (b) variable costs, such as labor and maintenance.
4. Differences in rates of production possible with varying types of equipment.
5. Effect on quality of product.
6. Working conditions and convenience.

Fuel or energy cost is of greatest consideration in those operations using large quantities of heat where labor costs are small, and differences in effect of various kinds of heat on spoilage, quantity, and quality are negligible, as in the smelting of iron. In the heat treatment of tools, labor costs and quality of output may govern; while in the baking of fancy pastries, quality is all important. Working conditions often influence the choice of kinds of heat because of the effect on morale, efficiency, and labor turnover.

The Use of Electric Energy.—The particular advantages of electric heat are claimed to be: (1) better quality of product; (2) saving in floor space; (3) saving in labor and less dependence upon labor for results; (4) greatly improved working conditions.

Electric heat has a wide use throughout industry. In the metal trades it is used extensively for annealing, melting, case hardening, tempering, and welding operations. The ceramics industry has applied it to annealing glass, firing china, and vitreous enameling; the chemical industry to

vulcanizing rubber, baking graphite, and drying operations. As an aid in the preparation of foods it is used for baking, roasting, and cooking. It contributes to the success of many finishing processes, such as drying paints and varnishes, enameling and japanning, sherardizing, etc. There are a multitude of miscellaneous and small applications, which in total use a large quantity of electric heat, and this field is to the greatest extent free from competition.

Of course, electric energy is not usually economical for bulk heating of low value products, for example, in the manufacture of brick and cement, where close control of temperatures is not essential to quality production. Each kilowatt-hour of electric energy gives 3,415 B.T.U. of heat energy, all of which is available at the point of use. With the current at 2¢ a kilowatt-hour it can be used for special applications, while a 1¢ rate permits a wide range of applications.

The complete utilization of all heat units paid for, utmost accuracy of temperature control, low labor costs, convenience, and favorable working conditions are characteristics of electric heat. The latter factor may outweigh a considerable price disadvantage. Temperature requirements of processes are automatically controlled, making the attainment of quality independent of the labor factor.

Heating elements may be of any size and placed where needed, as illustrated by the many common domestic applications of electric heat to curling irons, pressing irons, and water heaters for the sick room. Heating units are readily incorporated as parts of machines or placed in the floor and walls of ovens and furnaces.

Equipment costs for electric heat are high, but this is more indicative of the perfection of such equipment and assurance of low maintenance costs and dependability, than that other forms of equipment are more economical. Frequently more expensive equipment means greater speed of production, which in turn lowers unit costs. An instance may be cited of a high-pressure, gas-fired, semi-muffled furnace to operate up to 2,000 degrees F., which cost complete in all respects about $6,000. An electric furnace, complete with wiring, controls, etc., cost about $18,000. Both furnaces have the same advantages as to quality of work, convenience of operation, and cleanliness; but the electric furnace will produce nearly three times as much product as the gas-fired furnace produces.[11]

Sales-making characteristics in a product may possibly be attained only with electric heat, or at greater expense if fuel heat is used. Bottles annealed in electric lehrs do not break in bottling machines, eliminating

[11] "Comparison of Gas and Electricity for Industrial Heating," by R. C. Gosreau, *Chemical and Metallurgical Engineering*, Vol. 33, No. 6, p. 337.

a loss of 2% ; while a similar 20% loss in breakage was done away with in the manufacture of miniature lamps. Similarly, gears have been found to be stronger, copper wire more ductile, brass more uniformly soft and free from scale, and enameled goods to possess a more smooth, even finish than can otherwise be obtained.

Economy in processing is brought about in using electric heat, by savings in space occupied by equipment, comfortable working temperatures close at hand, possible elimination of intermediate or final cleaning operations, and lack of need for protective boxes, as no contaminating gases are produced. Absolute cleanliness prevails and all oxidizing action and open flames are done away with. Portability of many kinds of electrical equipment with ready attachment to any light socket is also an economy in first cost and convenience. There is a noticeable trend away from fuel heat to electric heat, particularly for small installations.

Methods of Applying Electric Heat.—Electric heat is utilized most generally by the (1) heating of liquids, (2) heating of solids, and (3) air heating or oven heating.

It is commonly felt that direct immersion is the most efficient method of heating any liquid, because the heat is then applied directly to the material. In some cases, however, the shape of the container or the nature of the liquid makes it necessary to use external heaters. . . .

It is practically impossible to heat tar and mastics with direct immersion heaters, because they will not absorb and transmit heat rapidly. Accordingly, steam-jacketed kettles are commonly used. Immersion heaters are then used to generate the steam which heats the kettles. . . .

Heating of solids is effected by direct contact of the heating elements with the material or heating the surrounding air. Cartridge heaters or space heaters are generally used. . . . In process work air may have to be heated to dry or bake certain materials. Also, it is often necessary to heat air in order to provide the correct temperature for mixing and promoting the reaction of certain materials. Normally this type of heating is done with space heaters.[12]

The Use of Gas.—Gas is suitable for heating many types of furnaces; for kilns, as in pottery and vitreous-ware establishments, and brickmaking; for brazing, soldering, japanning, bread baking, coffee roasting, heat-treating, annealing, and enameling operations, and many others. When standard industrial gas (containing 535 B.T.U. per cubic foot) is available at 75¢ per 1,000 cubic feet, it is claimed to be competitive, on a cost basis, with other sources of heat. In some localities

[12] "It's Easy to Apply Electric Heat," by W. C. Stevens, *Factory Management and Maintenance*, Vol. 95, No. 8, p. 82.

rates are as low as 50¢ or 60¢ per 1,000 cubic feet to industrial customers, on a demand and energy charge basis.

The wider distribution of natural gas has encouraged the perfection of gas-using equipments, and industrial gas engineers are making rapid progress in this respect. Often, gas-heating equipment is lower in first cost than electrical equipment intended for the same purpose, but standard equipment is not always available for many small and special applications, to which electric energy is so exactly suited. Other factors to consider in using gas are the presence of fumes, odors, need of manual control, noise, rates of output possible, and effect on quality.

Storage and handling are eliminated when gas is used, and as compared with coal and oil, more even heat distribution in furnaces is secured. It is clean, and simple to operate; more accurate temperature control is possible; and bills are payable the month following use rather than before.

The Use of Oil, Coal, and Coke.—The use of oil for producing industrial heat is competitive with gas for kilns, ovens, and the like, when fuel oil is cheap, and is used extensively where gas is not available. Low

TABLE 3. COST OF OPERATION OF ONE 700-POUND GAS-FIRED ROTARY CARBONIZING MACHINE

Furnace:		
Depreciation, $3,500 ÷ 10 yr.		$ 350.00
*Average interest at 6%, $\frac{11}{10} \times \$3{,}500 \times \frac{.06}{2}$		115.50
Maintenance and repairs including retort renewal		800.00
Gas Compressor:		
Depreciation, $1,450 ÷ 5 yr.	$290.00	
*Average interest at 6%, $6/5 \times \$1{,}450 \times \frac{.06}{2}$	52.20	
Maintenance and repairs estimated	200.00	
Total	$542.20	
Prorated to one furnace on basis of gas used		37.95
Total fixed expense per year		$1,303.45
Fixed expense per day $1,303.45 ÷ 306 days		$ 4.26
Power for furnace 8 kw-hr. at $.02		.16
Power for compressor, prorated per furnace, 40 kw-hr. at $.02		.80
Labor, 1 operator and helper at $1.40 per hour. × 24 hr. × 1/6 time		5.60
Gas, 11,550 cu. ft. at $.676 per M		7.81
Compound, 72 lb. at $.03		2.16
Total cost per day		$ 20.79
Total cost per M lb. treated, $20.79 ÷ 2.1 M lb.		$ 9.90

* Allowing for interest earned by depreciation reserve.

first cost is often its chief merit. More equipment is needed for utilizing oil than gas, as it must be combined with air and the mixture sprayed into the furnace under pressure. Storing and handling must also be considered, together with possible need for preheating in winter. Obviously, it is less flexible in use than gas, and requires more labor attention. For many installations the presence of oil is objectionable because of the resulting fumes, odors, and fire hazards.

Flue gases constitute a source of heat loss with fuels, and present other problems, although they may be utilized for various heating purposes. For example, waste heat from oil-fired kilns in a vitreous-ware plant is more than sufficient to operate the hot-water heating system for all its buildings.

The use of coal and coke involves handling the fuel and ashes, which is obviously objectionable in many places. Space requirements, greater difficulty of control, and slower operation are some of the disadvantages of these fuels.

CHAPTER 12

MAINTENANCE

The Function and Purpose of Maintenance.—Maintenance in industrial plants is the function of keeping buildings, equipment, and services in satisfactory operating condition. In order to make its work most effective the maintenance department will seek to anticipate and prevent interruptions in operation with consequent loss of output. An outline of the scope and responsibilities of the department has been summarized as follows:

The maintenance personnel has a primary interest in the selection, installation, operation, and upkeep of the plant equipment required to transmit, apply, and control the mechanical power and electrical energy used in operatin~~g the~~ production equipment; and in the procurement and use of the supplies and tools required for the upkeep of buildings.

The maintenance personnel is responsible for maintaining all shop services, including transportation and materials handling; and for the procurement, storing, and disbursement of the necessary supplies and replacement parts.

The maintenance personnel is responsible for the upkeep of all production equipment, its regular inspection, cleaning, lubrication, and repair; for the keeping of inspection and performance records of auxiliary equipment; for the proper supervision, planning, and scheduling of maintenance work; and for the clerical work appurtenant thereto.

The maintenance personnel is concerned with the recording, analysis, estimating, and control of maintenance costs.[1]

The Maintenance Department.—In small plants maintenance activities are combined with the work of other departments, such as the engineering department, production department, or the work of the plant engineer. In large plants the work is organized separately, with an executive in charge who reports directly to a works manager or manufacturing superintendent. Table 4 gives the results of a survey made to determine the place of the plant engineering department in different plants, the work done, and to whom the person in charge reports.

[1] "Maintenance Organization and Management," by L. C. Morrow, *Factory Management and Maintenance,* Vol. 93, No. 12, p. S-149.

TABLE 4. PLANT ENGINEERING FUNCTION IN 15 PLANTS *

Size of Plant		Products Manufactured	Title of Individual in Charge of the Plant Engineering Function	Kind of Work Included as part of the Plant Engineering Function	Position of Plant Engineering Organization to Organization as a Whole
Number of Employees	Motor Horsepower				
15,000	18,000	Automobiles	Plant Engineer	Electrical, mechanical, and building maintenance.	Plant engineer reports to factory manager.
7,700	11,512	Cash Registers	Maintenance Engineer	Electrical, plumbing, millwrighting, plant inspection, outside and landscape, factory layout, power house, construction.	Maintenance engineer reports to plant superintendent.
4,200	4,650	Automobiles	Plant Engineer	Maintenance (electrical, carpentry, pipe fitting, painting, millwrighting, tinsmithing, janitor service).	Plant engineer reports to factory manager.
2,100	9,000	Steel Building Materials	Chief Mechanical Engineer	Plant electrical engineering, plant mechanical engineering, both including maintenance.	Chief mechanical engineer reports to general works manager.
2,000	1,600	Vacuum Cleaners	Maintenance Superintendent.	Millwrighting, carpentry, electrical.	Maintenance superintendent reports to vice-president in charge of manufacture, who is also works manager.
1,500	315	Inter-plant Communication Systems	Plant Engineer	Mechanical maintenance, electrical maintenance, carpentry.	Plant engineer reports to factory manager.
800	1,500	Nitrocellulose, Acid	Master Mechanic	Mechanical and electrical maintenance.	Master mechanic reports to assistant superintendent.
800	750	Gasoline Motors	Master Mechanic	Electrical, and mechanical maintenance, plumbing, carpentry, millwrighting, painting, janitor service.	Master mechanic reports to works manager.
800	650	Cameras	Buildings Superintendent, Chief Electrician, and Machinery Maintenance Superintendent.	Building superintendence and maintenance, plant electrical engineering, machine repair and other mechanical maintenance.	The function is divided among three men whose activities are coordinated by the chief engineer and general superintendent.
600	7,000	Linoleum	Plant Engineer	Plant electrical engineering, power plant, safety, maintenance, pipe fitting, carpentry, machine shop.	Plant engineer reports to plant superintendent.
600	900	Locomotive Cranes and Steam Shovels	Maintenance Foreman, Mechanical and machine; and Maintenance Foreman, Electrical.	Mechanical and building maintenance, electrical maintenance, millwrighting, carpentry.	Both maintenance foremen report to the general superintendent.
560	1,000	Rubber Products	Plant Engineer	Electrical maintenance, mechanical maintenance, millwrighting, carpentry, painting, pipe fitting, masonry, janitor service.	Plant engineer reports to chief engineer.
550	2,000	Wringers, Mouse and Rat Traps, Hockey Sticks	Chief Engineer	Master mechanic's duties, maintenance foreman's duties, electrical foreman's duties.	Chief engineer reports to plant superintendent.
300	1,650	Confectionery	Plant Engineer	Consulting engineer's duties, chief electrician's duties, carpentry, yard labor, plant protection, painting, machine shop, steam fitting, tinsmithing.	Plant engineer reports to factory manager. Plant engineer is also mechanical and division superintendent.
160	3,500	Paper	Plant Engineer	Chief engineer's duties, chief electrician's duties, and master mechanic's duties.	Plant engineer reports to president; master mechanic reports jointly to plant engineer and supt.
37,670	64,027	Total plant employees and motor horsepower represented by the 15 plants.			

* From "A Practical-Ideal Organization for Plant Engineering," by L. C. Morrow, *Maintenance Engineering,* Subscriber Service Survey No. 4, p. 8.

The Organization of the Maintenance Department.—The organization of this department varies widely with its size and the scope of the work for which it is responsible. The Westinghouse Electric and Manu-

facturing Company, East Pittsburgh, Pa., consolidates the maintenance function in a department called the Buildings, Light, Heat and Power Department. This is divided into five sub-departments: i.e., Works Engineering, Power Plant, Buildings and Grounds Maintenance, Light, Heat and Electrical Planning and Layout. The scope of its work includes selection, installation, and prevention of breaking down of equipment.

The maintenance work in many plants is divided into three groups; namely, electrical, building, and mechanical activities. The various

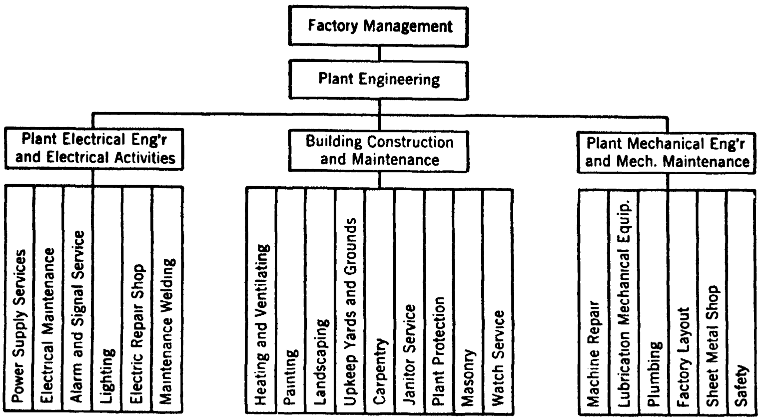


Figure 31. The Plant Engineering Function

(From "Maintenance Organization and Management," by L. C. Morrow, *Factory Management and Maintenance*, Vol. 93, No. 12, p. S-151.)

phases of these tasks are indicated in Figure 31. In small companies various maintenance foremen such as millwright, plumbing, electrical, mechanical, etc., will report to a master mechanic. In these instances the maintenance function will be restricted to repairs, inspections, and the making of minor changes and installations. Some companies depend upon outside organizations for certain phases of the work, such as the design and installation of power equipment, inspection and maintenance of elevators or roofs. Figure 32 shows an organization for maintenance in a plant of medium size. In a smaller plant the same activities would be carried on, but there would be less specialization among the workers. In Figure 33 the scope of work is widened to include responsibilities pertaining to new construction and operation of the power plant. Figure 34 shows an organization chart for a larger company.

Regardless of the number of employees, kind of product, and age of plant, the variation in proportion of maintenance men to the total plant

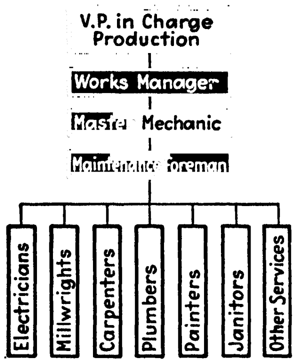


Figure 32. Maintenance Organization in a Medium-Sized Plant

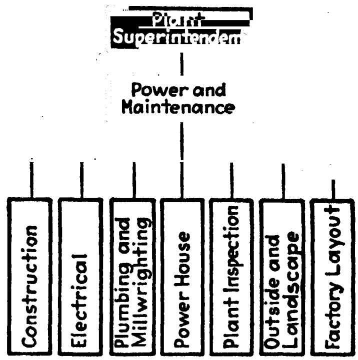


Figure 33. An Organization Including Power and Maintenance

(From "Maintenance Organization and Management," by L. C. Morrow, *Factory Management and Maintenance*, Vol. 93, No. 12, p. S-151.)

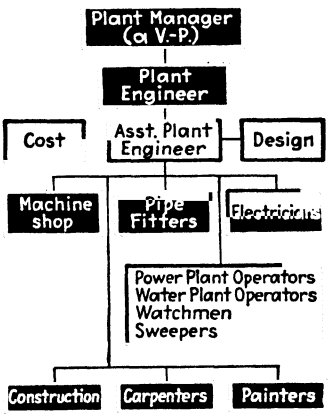


Figure 34. Chart Showing the Duties and Responsibilities of a Plant Engineer for a Large Company

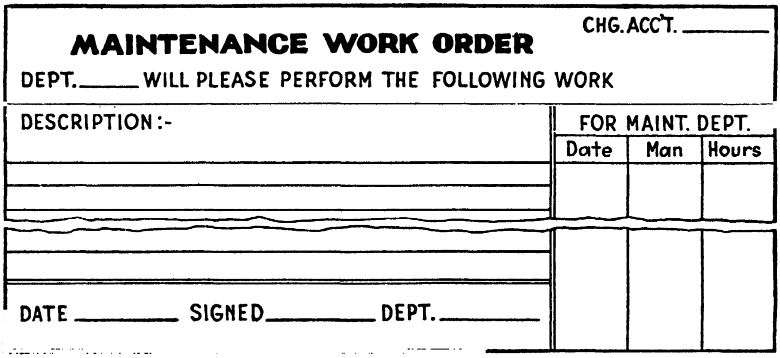
(From "Maintenance Organization and Management," by L. C. Morrow, *Factory Management and Maintenance*, Vol. 93, No. 12, p. S-151.)

employees lies between 4% and 10%. This variation is greatly influenced by the number of janitors, sweepers, watchmen, and yardmen employed, who may comprise about one-half of the group.[2]

Maintenance Orders.—Orders for repairs usually originate with the department foremen. A simple form for such work is shown in Figure 35. The original copy goes to the maintenance department, and a duplicate is

[2] "Variations in Maintenance Costs and Procedure," by E. V. Stoody and G. I. Ross, *Maintenance Engineering*, Subscriber Service Survey No. 7, p. 10.

retained by the foreman. Material is withdrawn from stores on a standard requisition form. When work is finished, the filled-in work order goes to the cost department.



MAINTENANCE WORK ORDER CHG. ACC'T. ______

DEPT. ______ WILL PLEASE PERFORM THE FOLLOWING WORK

DESCRIPTION :-	FOR MAINT. DEPT.		
	Date	Man	Hours

DATE ______ SIGNED ______ DEPT. ______

Figure 35. A Maintenance Work Order Form

(From "Maintenance Organization and Management," by L. C. Morrow, *Factory Management and Maintenance*, Vol. 93, No. 12, p. S-153)

For major repairs an order signed by the foreman may need to be approved by the head of the manufacturing department and the executive in charge of maintenance. Additional forms may be needed in connection with material and cost control, inspection, and for reports to interested executives.

Authorization for money expenditures must usually originate with the foreman. This is because he is responsible for production costs, of which maintenance is a part. Exception to this rule may be merited in cases where a temporary saving or delay in making repairs would entail unwarranted expense later, where costs are chargeable to plant expense, or are part of an authorized program.

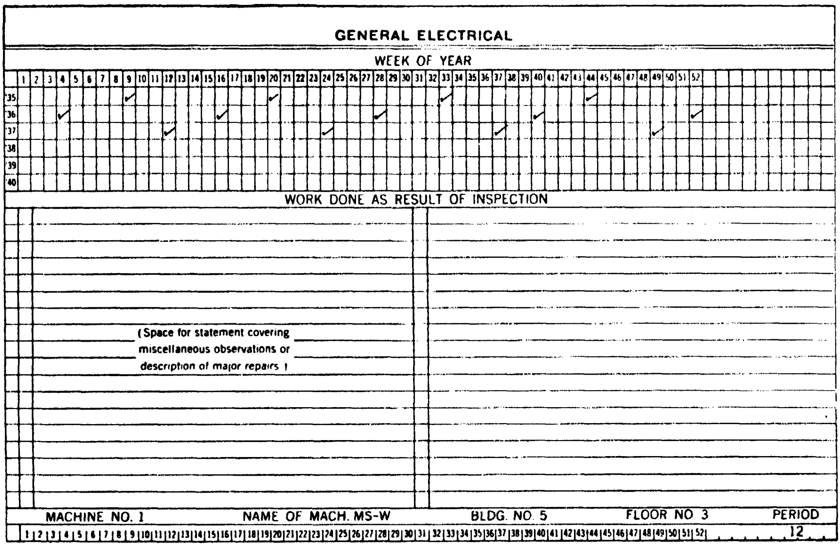
Inspection for Maintenance.—An important function of the maintenance department is to prevent breakdowns and thus avert losses due to interruptions to production, and to minimize the cost for repairs by noting the need for them at early stages. An effort is made to anticipate troubles, and to apply the remedy in advance. Under a general maintenance inspector there will be inspectors covering mechanical equipment and machines; electrical equipment, installations and wiring; buildings and grounds, etc. The tasks of each inspector or group of inspectors become more specialized as the work increases.

Regular inspection schedules are a feature of preventive maintenance which guards against work interruptions. Inspection should not only dis-

close deficiencies but the causes for them. Responsibility for misuse or negligence in connection with the operation of equipment may thus be allocated.

Inspection Records and Schedules.—An example of records and time schedules for inspections is provided by the practice of the Carborundum Company, Niagara Falls, N. Y.:

A separate insert or card should be used for each unit or section of equipment. (See Figure 36.) In addition a separate insert should be used for each distinct inspection function such as mechanical inspection, lubrication, or oil change. These functions may be consolidated on one card and distinguished by colored flags; however, that will be less satisfactory. The bottom of the insert is divided into 52 spaces representing weeks of the year. These serve to indicate, by means of a green celluloid movable tab or flag, the scheduled week or date when a particular inspection is due.


GENERAL ELECTRICAL

WEEK OF YEAR

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52

'35
'36
'37
'38
'39
'40

WORK DONE AS RESULT OF INSPECTION

(Space for statement covering miscellaneous observations or description of major repairs)

MACHINE NO. 1 NAME OF MACH. MS-W BLDG. NO. 5 FLOOR NO. 3 PERIOD

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 12

Figure 36. Equipment Index of the Inspection System

The frequency of these inspections, as previously determined according to the nature and use of the equipment, is indicated at the right by a number signifying weeks. In case of special consideration being required a red flag may be used to indicate a special inspection. Proper spaces are shown for indexing the equipment.

Near the top of the card is a similar division for 52 weekly periods, with a vertical index which is good for at least five years. The purpose of it is

that in case an inspection work card, to be described, is returned marked O. K., a check mark can be recorded in the proper location indicating the inspection completed and conditions satisfactory. If the inspection notice is not recorded, and if extensive repairs have been made, an index number may be recorded and under it a brief entry can be made describing the nature of the repairs. The back of the card may also be used.

When the flag on the insert indicates that an inspection is necessary an inspection work card is filled out. (See Figure 37.) On this card are shown spaces for equipment location, and an index of all general types of inspection, one or a number of which can be checked to indicate the type of work to be done, thereby eliminating written instructions by the clerk.

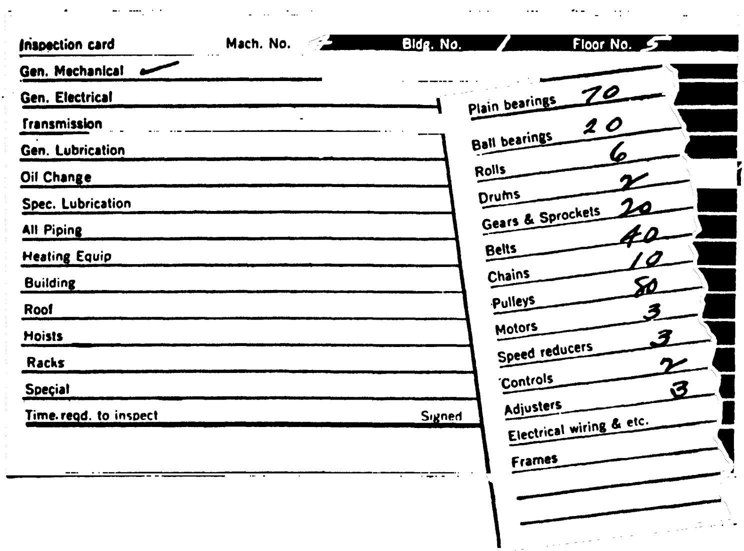


Figure 37. Inspection Work Card Issued to Inspectors

After all equipment has been indexed and catalogued as described, inspection periods determined and the flags arranged so that all work does not fall due at one period, the system is ready to be operated. The best arrangement is to have about the same number of jobs scheduled weekly.[3]

In making inspections it often proves advisable to have listed on the form given to the inspector the points to be noted in making the inspection, in order that a complete and thorough job be accomplished. The inspector will then check each item on the form as he does his work, in-

[3] "Preventive Maintenance," by J. A. Williamson, *Maintenance Engineering*, Subscriber Service Survey No. 4, p. 17.

dicating opposite any items needing attention just what repairs were required. (See Figure 38.) Check sheets of this kind are similar in principle to the lubrication charts for automobiles provided to attendants at service stations, and accomplish the same purpose.

Frequency of Inspection.—Frequency of inspection of many items will need to be determined by judgment and from experience. Sanitation may be a factor in some cases; safety, wear and tear, or production delays,

Conveyor Inspection Report No. 31

Conveyor No. *23* Section *F-12* Date *2-10-* Inspected By *G.Riling*

Motor *O.K.*
Motor drive chain is loose

Controller *Contacts burnt*

Push Button Control *O.K.*

Signal Bell

Worm

Worm Gear

Bearings *One bolt loose in drive shaft bearing*

Shafts and Collars *O.K.*

Gears *O.K.*

Sprocket Wheels *Set screw loose*

Sprocket Chains *O.K.*

Rollers *Bracket bent*

Load Carriers *O.K.*

Chain Guides *O.K.*

Conveyor Frame *Loose bolt in second hanger*

Guards *O.K.*

General *Clean*

Figure 38. Inspection Sheet

in others. In some plants cooperation of the working group is enlisted in inspection work, either by a committee plan of recommendations for shop upkeep, or by penalties for breakdowns which should have been averted by alertness of the operators concerned. Figure 39 shows a

CONTINUOUSLY	MONTHLY	QUARTERLY	SEMI-ANNUALLY
1. All Construction 2. Completed Jobs 3. Yards 4. Drinking Fountains 5. Piping (a) Air (b) Water (c) Hydraulic (d) Gas (e) Oil (f) Steam 6. Electric Wiring 7. Ladders 8. Electric Signs 9. Roofs 10. Fire Doors 11. General Safety	1. Cranes 2. Jibs 3. Elevators 4. Dumbwaiters 5. Conveyors 6. Special Lifting Devices 7. Chain Blocks 8. Hoists (a) Electric (b) Air 9. Crane Runways 10. Trolley Wires 11. Slings (a) Chain (b) Wire Rope (c) Manila Rope 12. Switchboards (a) #1 Pwr. Hse. (b) #2 Pwr. Hse. (c) MF Substa. 13. Tunnels 14. Melting Pots 15. Ovens 16. Furnaces	1. Test Floors 2. Cable Tunnels 3. Sewers 4. Gasoline Tanks 5. Benzol Tanks 6. Floor Loadings	1. Outdoor Substation 2. Pole Lines 3. Outdoor Power Lines 4. Buildings 5. Fences 6. Bridges 7. Walks 8. Driveways 9. Fire Escapes 10. Stacks 11. Manholes 12. Safety Belts
WEEKLY		**MONTHLY** *(Continued)*	
1. Pressure Tanks 2. Shop (Regulations Committee) 3. Ventilating, ZX-1 4. Exhausters, E & I 5. Blowers, H-1		17. Enameling Towers 18. Kitchen Equip. 19. Elec. Welders 20. Portable Elec. Grinders 21. Lead Covered Power Cables 22. Power Transformers 23. Maintenance Dept. (a) Mach. Tools (b) Storesrooms (c) General	Note: This does not include Fire Fighting Apparatus and Systems (Being Covered by another Department)

Figure 39. Schedule of Routine Inspection

schedule for routine inspection in effect at the Westinghouse Electric and Manufacturing Company plant.

Methods and Extent of Maintenance—Buildings.—Maintenance of buildings calls for a variety of work. Outside walls should be inspected for cracks and openings around windows, and for disintegration of mortar joints. Necessary repairs may be effected using either a cement mortar or a never-hardening pointing material for open joints, and oakum and mastic calking compound about windows. Windows should be washed at least twice a year, broken panes repaired, defective putty replaced, and any necessary painting done. Roofs fail most often where flashings occur. They should be looked over once a month and thoroughly inspected twice a year. Roofs guaranteed and protected by a surety bond will be repaired by their makers. A mop coat of hot composition is recommended for built-up roofs every five years. The service of specialists in this work is recommended. Foundations and footings need to be checked for settlement and imperviousness to water. It is better to

repair leaky walls of concrete from the outside, raking out any cracks and cutting back the edges to form a V-shaped groove. These can be filled with cement mortar packed in tight with a tool. The wall surface can then be given a coat of cement mortar, scratched rough to receive a second coat before the first becomes hard. Mop coatings of pitch or tar are also effective. Exterior painting needs renewal every two or three years, perhaps oftener where conditions are particularly adverse. Interior painting should be checked for light reflection and appearance once or twice a year. Maintenance of floors is most often made necessary by overloading or improper installations. Concrete floors are repaired by patching; mastic floors by filling cracks or applying heat to close cracks; wood and wood block floors by renewal of worn sections, or steel plates may be laid to protect areas of excessive wear. Prevention of accidents is an important factor in floor maintenance.

Elevators.—Various types of elevator maintenance are offered by manufacturers. The service department of the Otis Elevator Company operates in 178 cities. The simplest service covers an ordinary examination with resulting report to the owner on the condition of the apparatus. The next type of service is examination at regular intervals, including the lubrication of the apparatus and adjustment of the parts. Another service provides these same features and in addition replacement, without additional charge, of small items, such as carbon and copper contacts, springs, washers, etc. A complete service covers regular examination, cleaning, lubricating, adjusting, furnishing of all parts required, making repairs, including new ropes which may be needed during the life of the contract. This service is at a fixed cost, expert, and assures continuous operation and safety. Emergency service is available day or night. If inspection and maintenance of elevators is done by plant employees they should be specially instructed in the work and inspections made at regular intervals.

Heating and Ventilating Equipment.—Periodic inspections should disclose operating deficiencies in piping systems, radiators, valves, and traps. Minor and necessary repairs may be needed, but others may be postponed until the late summer when the entire system can be given attention and made ready for another heating season. Parts of the ventilating and air conditioning equipment, such as fans, motors, pumps, etc., may need daily attention. Otherwise, maintenance of unit heaters and of air conditioning equipment is almost negligible.

Power Equipment.—Shafting needs to be checked for proper alignment, loose hanger bolts watched for, and lubrication attended to. Power

drives need to be looked over. Motors require technical attention to check loads, insulation, and to note probable damage due to moisture or dust, and condition of minor parts. Lubrication and cleaning should be periodic.

Sanitary Facilities.—The maintenance of wash rooms and plumbing fixtures generally consists of proper janitor service and attention during the day. Matrons on duty in women's rest rooms will report any fixtures out of order, and prompt attention should be given to them. Periodic inspections will, of course, be made throughout by the maintenance department. A cleaning department will thoroughly clean all fixtures every night, and check the mechanical functioning of all faucets and equipment. Floors of wash rooms should also be scrubbed at these times. Locker rooms should be cleaned daily and scrubbed weekly, or oftener, as required. Supplies of towels, soap, and toilet paper should be replenished each day, containers being provided for soiled towels. The attractiveness and cleanliness of sanitary facilities influences employees to use them properly, minimizes repairs, and promotes sanitary habits and conduct. Employee morale is influenced by the adequacy and attractiveness of personal service facilities.

Drinking water fountains should be of impervious vitreous material, with a jet of nonoxidizing material. A daily or semi-daily cleaning should be thorough, not only of the fixture, but of the area immediately adjacent.

Fire Protection Equipment.—Fire extinguishers should be recharged immediately after use, and at least once a year. Any damaged or frozen extinguishers should be reconditioned by the maker. Unlined linen hose deteriorates when left wet. Fire buckets must be kept filled. The addition of calcium chloride to the water, 5 pounds for each gallon, will protect it from freezing down to 10 degrees below zero. Sprinkler systems must be protected from freezing, and the heads free from corrosion, paint, or dust deposits. The water supply should be checked as to quantity, and the proper working of pumps and equipment tested periodically. Dry-pipe systems must be checked for leakage of valves which may cause ice to form in the pipes and prevent their functioning when needed, if the proper air pressure has not been maintained.

Yard hydrants may freeze due to leakage or poor drainage. They may be thawed out by using steam or hot water with unslaked lime added. Hydrants should be flushed and oiled about twice a year. Fire doors and fire windows should be inspected to see that they work freely and smoothly, and that all automatic devices are in order. Materials and

equipment must not be piled against them so as to hinder proper closing or obstruct passage.

Control of Maintenance Costs.—Maintenance expenses may be (1) based upon production cost, units of output, or labor hours; (2) controlled by a budget; or (3) simply paid as incurred on a basis of need. In (1) a relation may be established on the basis of production cost in dollars, the amount allotted may vary with the units of output, or a ratio established between hours of maintenance and hours of productive labor. In (2) the preparation of a budget suggests previous experience and a consideration of the needs during the period in question. Proposed expenditures may be charted to show estimates in accordance with the kind of work and by weeks or months. Actual expenditures may be checked against these figures. When maintenance work is carried on as indicated in (3), results depend upon intelligent direction and close supervision of the work. Labor costs may be reduced by some form of bonus system, providing time standards have been established for the tasks performed; otherwise they are likely to be excessive.

Depreciation on buildings, the upkeep of grounds, and some other maintenance department expenses are largely independent of the volume of production, but departmental maintenance costs show a closer relationship. One company varies expenditures for departmental upkeep on a sliding scale from a minimum at 30% activity to a maximum at 85% activity.

Time Standards and Incentives for Maintenance.—It is recognized that maintenance work involves doing many different kinds of work. Likewise the conditions surrounding jobs vary, as does the extent of each task. Nevertheless it has been found possible and feasible to analyze such work, measure tasks in terms of work time and effort, and establish plans for compensating workers which reduce costs. Savings of from 25% to 50% are usual, with increased earnings for the workmen of from 15% to 20%.

In plants where time study service is not available, progress toward greater effectiveness can be made by keeping complete records of work done. An analysis of such data together with experience provides a rough basis for setting job times. Workers may be paid a regular hourly rate, and in addition for part of the time saved.

Time study departments analyzing maintenance work proceed to establish standards for each kind of work with respect to equipment, methods, and working conditions. They then study each element of a particular task separately, arriving at performance times which are

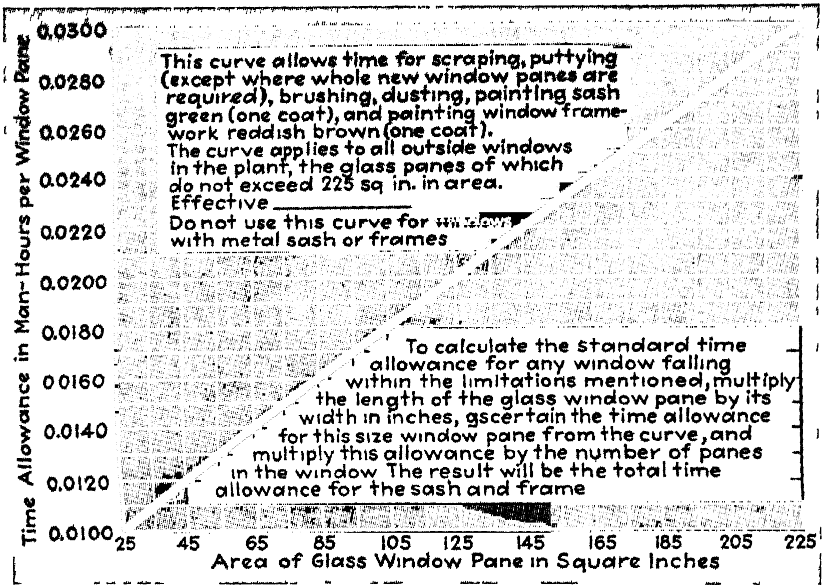


Figure 40 Time Allowance for Window Paintings

(From "Paint as Maintenance, Paint as Production" by T J Maloney, *Maintenance Engineering*, Subscriber Service Survey No 7, p 23)

STANDARD TIME Routing No

Dwg Title	Sec L-13	Style Pattern		Dwg No	Sub
Part *Sec M C. Lot 1 to 11*		Ins Spec		Item	
Mtl Size	Pcs per 100 lb.	D e Mold		L Space	Sub
Mach Tool and No		Spec Tool or Fixture		STANDARD TIME Set up	Each Piece
Operation *Spray & hand paint*		Oprn No	Class of Labor / How Set		*1140 00*

Spray and paint end wall	*45 00*
" " " Bay No 1	*47 00*
No 2 3 11 12	*200 00*
No 4 5 6-7 8-9 10 13 14-15 16	*561 00*
No 17	*90 00*
	943 00
Get material to job and set up scaffold	*110 00*
Group leader	*30 00*
	1083 00
Spray and paint 18 columns from 1st to 2nd floor	*30 00*
" " " storeroom partitions & other partitions	*15 00*
	1128 00
Time taken 1020 88 hours	
111 7%	

Recorded-Time Clerk Cost Clerk Date Signed Time Study Dept

Figure 41. Estimate of a Westinghouse Painting Job

(From "Paint as Maintenance, Paint as Production," by T J Maloney, *Maintenance Engineering*, Subscriber Service Survey No 7, p 23)

reasonable for the average man hired for that kind of work. Figure 40 shows a chart prepared covering time allowances for painting windows. Figure 41 shows an estimate made for a painting job using similar data, and the actual time taken.

Incentive wages for maintenance workers performing tasks covered by time standards are provided by the application of incentive wage plans as described in the chapters on wages.

Maintenance Records.—The permanent records of the plant maintenance department should cover the location of every important feature of the entire plant and all permanent records of the physical plant. Among these are:

1. Property maps.
2. Building plans and specifications.
3. Power plant plans and specifications covering buildings and equipment.
4. Underground piping maps.
5. Maps of all factory piping, including steam, power and heat, water (hot and cold), service and drinking, fire equipment (sprinklers, hydrants, and play pipes), as well as giving the location of fire fighting apparatus and exits.
6. Layout of shop mechanical handling facilities.
7. Perpetual inventories of machinery and equipment.
8. Drawings and specifications of machinery and equipment with list of parts convenient for use in ordering replacements.
9. Records of inspections, adjustments, repairs, and costs.
10. Machine and departmental layouts.

A record of piping is secured by painting and other markings to indicate the fluid that is transmitted. Standard colors are used.

The Housekeeping Organization.—The organization of the janitor, cleaning, and sanitation service for industrial plants has not been standardized. It is essential to know what is to be done, how it is to be done, and when. This implies planning of the work, and its scheduling. As a basis for this time standards may be developed covering all phases of the routine work, and an incentive wage plan evolved as a stimulus to effective effort. With adequate data of this kind at hand, work charts may be prepared and expense budgets determined. Substantial savings may be expected to accrue as a consequence of the definite knowledge gained and a check made upon accomplishment as against planned expectations.

CHAPTER 13

MATERIALS HANDLING

Economies Secured with Good Shop Transportation.—Rising costs and keen competition have forced plant managers to consider the savings that can be effected by efficient systems for handling materials. In past years so much emphasis has been placed upon the perfection of machine processes and their contribution to rapid and low cost manufacturing, that other ways of facilitating work and lowering costs have not received merited attention. Yet, when analyses of production troubles are made, many are found to be the consequence of poor management in handling work in process.

A condition which has delayed general recognition of the part played by material handling equipment has been the lack of cost information. Material handling is fundamentally a connecting link between various production machines or operations. As a consequence the facts about handling costs have been hidden away in overhead charges.

The problem of shop transportation involves moving materials economically and eliminating as completely as possible nonproductive labor and time between operations. Surveys indicate that handling costs in factories amount to from 5% to 80% of the productive labor payroll, and that processing or operating time may be but a small per cent of over-all manufacturing time. In many plants much saving may be effected. Good materials handling tends to (1) increase the efficiency of productive labor, (2) increase the productivity of equipment and floor space, (3) decrease the volume of goods in process, (4) eliminate nonproductive labor, and (5) lower the direct costs of handling materials. Benefit may also accrue in (6) simplifying production control, (7) reducing damage incurred by handling, and (8) more accurate scheduling of completion dates.

Materials Moved Govern Kind of Equipment Selected.—The nature of the materials to be moved influences the choice of handling equipment. There are differences as to kind, weight, quantity, bulk, perishability, value, and destructive qualities. Liquid and bulk materials which can be handled in fluid form are common in the continuous flow industries, of which flour mills, starch factories, and bottling plants are typical. On the other hand, in assembly industries where machine manu-

facture is employed, materials are in unit form. Fluid material may be handled in pipe lines, chutes, or on belt conveyors by a continuous movement. While weight, bulk, distance, quantity, and other characteristics influence the selection and design of proper equipment, ordinarily very large quantities can be handled mechanically at a lost cost. Unit materials more often require loading and unloading and individual handling at operation points. Small parts may be contained in pans or tote boxes, or quantities stacked on trucks. Larger pieces may need to be handled separately either on trucks, conveyors, or by overhead devices.

Fixed and Flexible Types of Equipment.—In the continuous type of manufacture a fixed route prevails and the variety of principal materials may be limited to but one kind, as in the making of cement, brick, or flour. In these instances transportation facilities are designed "into" the plant structure and arrangements, and function as a part of the production machinery. The manufacture of a single standard product or of parts which go through the same sequence of machine operations, permits the establishment of fixed lines of travel also. The facilities needed for movement of parts can be predetermined accurately and provided in the form of conveyors, belts, cranes or other devices which are also built in. These devices serve to interlock machine operations and unify the plant as a whole.

When several departments and many machines are used in the production of a variety of articles, some form of trucking is more likely to be resorted to because of the many different material routes. Likewise transportation facilities for a jobbing business must be adapted to moving goods along any route chosen. Orders are unlike and parts differ in size and kind. Such conditions call for a flexible system of shop transportation.

Materials which are easily damaged by handling must be given protection as they move along. Contact may injure surfaces or destroy finishes; fragile items must be kept separate and not jolted, and valuable items must be protected against theft. Acids, if not handled properly and carefully, may cause accidents or property damage, and the same applies to hot metals in foundries, to explosives, and to heavy machine parts.

Classification of Handling Devices.—A general classification of material handling equipment might be:

1. Lifting and Lowering Devices
2. Transporting Devices
3. Devices Which Both Lift, or Lower, and Transport

Various devices are grouped under these three main headings, according to whether they are mainly used to move their loads vertically, horizontally, or to both lift and carry.[1]

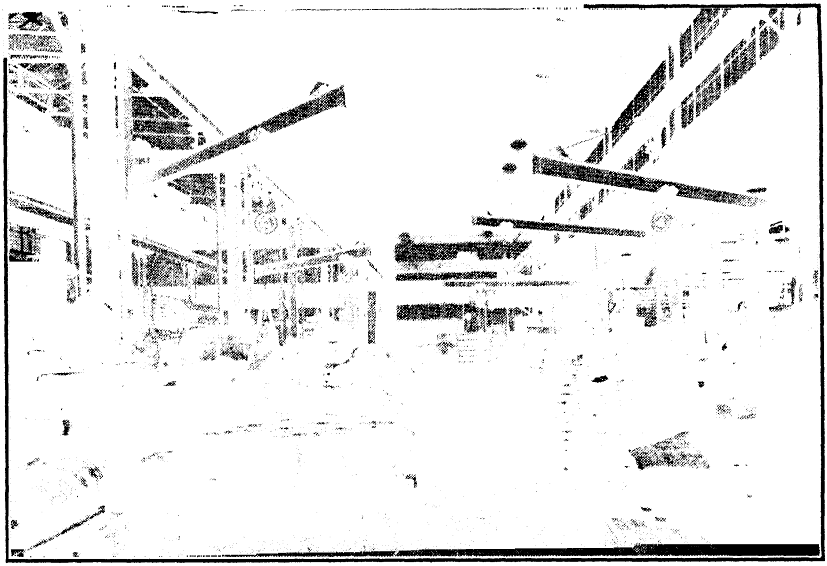
A very simple transporting device not ordinarily included in equipment lists consists of a flat steel plate with front edge turned slightly upward and with chains for attaching to a truck or tractor. This may be dragged over wood block and other heavy duty floors without objectionable abrasion, and used to carry parts, packages, or boxes.

Hoists.—There are three principal types of hoists: those operated by chain, by air, and by electricity. They may also be classified as those which are in fixed positions and those with trolleys running on overhead rails. The chain hoist, hand operated, is adaptable to almost any service and is particularly desirable where other forms of power are not available, or the cost of more expensive equipment is not justified. Ordinary sizes range from one-quarter ton to two or three-ton capacities. They are light in weight, portable, easily and safely operated. Ten-ton equipment is obtainable.

Air and electric hoists enjoy a wide range of usefulness for handling both light and heavy loads. They accomplish the work of many men rapidly, economically, and easily. Fragile materials are handled without damage. Hoisting apparatus of this kind attains greater usefulness when equipped with roller bearing trolleys and given a horizontal as well as vertical range. Air hoists range, as a rule, up to five tons, but may be had in capacities up to twenty tons. Electric hoists may be obtained in almost any desired capacity. On overhead cranes electric hoists are frequently designed for loads of 100 tons or more. The expense of installing and operating an air compressor is a factor to be considered, although if compressed air is needed for other operations, it may be the cheapest form of power. Electric power is usually more available for hoists than air, even though direct current is required, but the fire or explosion hazard introduced by electrical equipment may affect the choice.

Elevators.—Elevators are of several types. The familiar platform freight elevator is used to transport from one floor to another over a fixed vertical route. The merit of this type is its ability to carry different kinds of material, serve several floors, and form the connecting link in many independent material routes served by different types of equipment. Moving equipment, such as trucks, may be carried as part of the load.

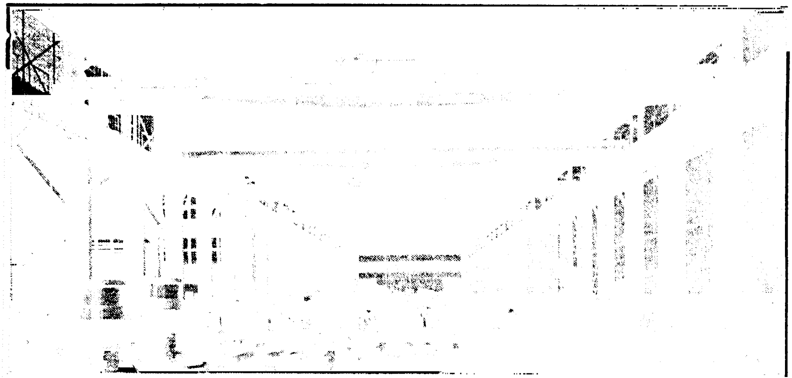
[1] For more information as to kinds of equipment, operation characteristics, capacities, and economy of use, see Cost and Production Handbook, Sec. 17.



(Courtesy of Wright Manufacturing Division of American Chain & Cable Company, Inc.)

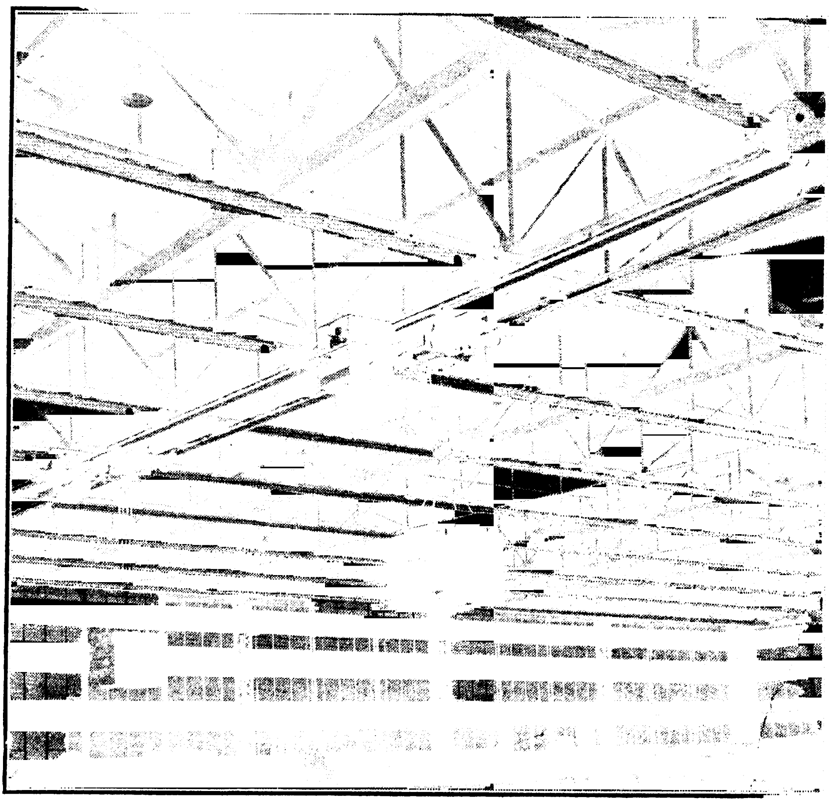
Figure 42. High Speed Hoist and Jib Crane Installation Serving Boring Mills

Figure 43. Use of Electric Magnets for Picking Up Pig Iron. A Roller Conveyor in the Background Is Used to Unload Cars



(Courtesy of The Austin Co.)

Figure 44. For Handling Heavy Machine Parts, Overhead Cranes Are Essential

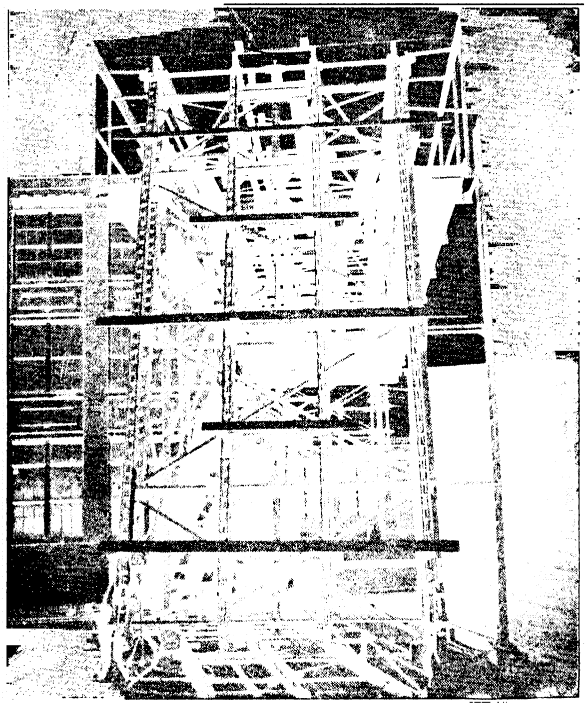


(Courtesy of American Monorail Co.)

Figure 45. A 160 Foot Double Bridge Crane with Cage Hoists in Aircraft Assembly Plant

Crane is propelled by rubber wheels under each of the nine runways.

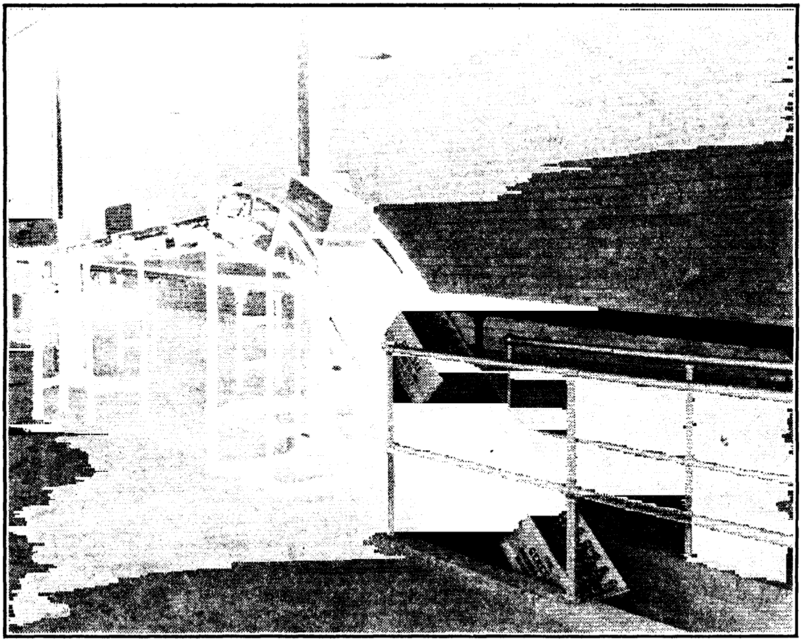
Special types of elevating equipment which handle package or unit materials only are in use, such as the arm elevator and suspended tray types. The suspended tray elevator consists of a series of pivoted suspended trays attached to two strands of endless chains or cable running over top and bottom sprockets or cheaves. As the tray travels upward, its projecting fingers pick up the load, which has been momentarily resting on the loading arms, carry it over the top and deliver it at the desired



(Courtesy of Gifford-Wood Co.)

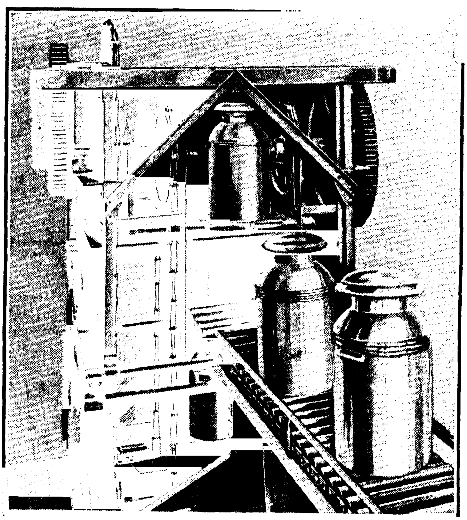
Figure 46. A Lumber Elevator and Conveyor

floor on the down side. Horizontal runs may be added to the usual vertical section. With this equipment empty containers may be returned on one side while filled carriers are being lifted on the opposite side. It is not adapted to handling a wide range in sizes of articles because of the difficulties in providing automatic loading and unloading, but the use of gathering boxes overcomes this objection, at least partially. The arm elevator is best adapted to handling objects of uniform size, such as barrels, bales, boxes, or bags. With the finger-arm carriers in most



(Courtesy of The Lamson Co.)

Figure 47. Push Bar Type of Elevator in Combination With Gravity Roller Conveyor

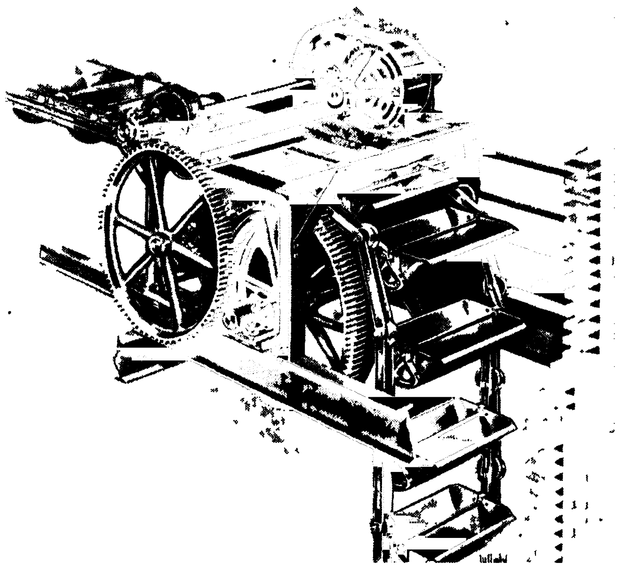


(Courtesy of Gifford-Wood Co.)

Figure 48. Vertical Elevator Handling Milk Cans, Automatic Loading and Unloading

common use packages are picked up automatically from the loading fingers or stations at any floor on the up side and discharged over the top only. For gravity lowering, controlled by small motors or mechanical brakes, this type has also found a fairly wide field of application. Automatic loading and unloading from and to other conveyors is sometimes arranged.

Bucket elevators consist of a series of buckets mounted on or carried by one or two strands of chain or belt. The buckets may be spaced either some distance apart or close together. Their function is to elevate or



(Courtesy of Link Belt Co.)

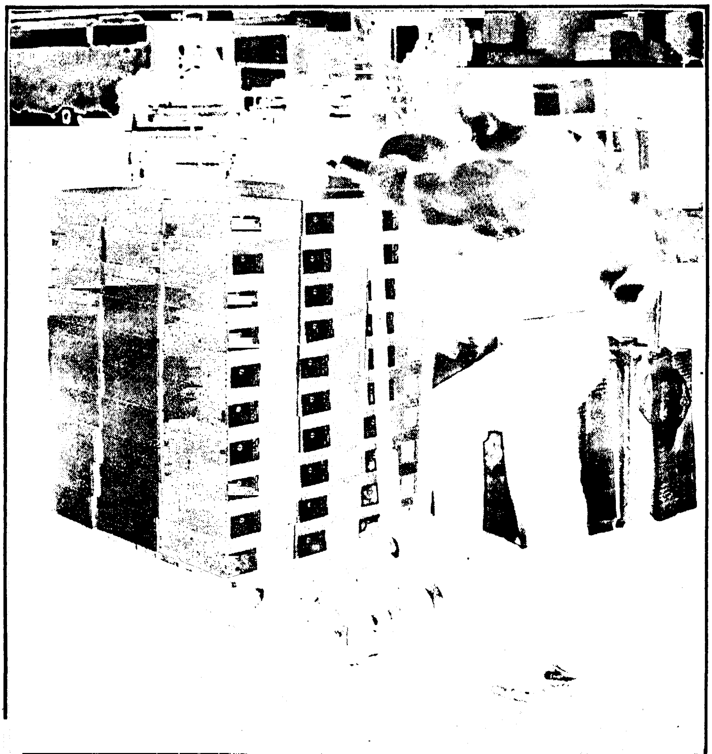
Figure 49. Elevating and Conveying Sections of Bucket Conveyor

lower material from one level to another and they may be operated in vertical, horizontal, or inclined positions. In one form or other they are adapted to handling any kind of loose bulk material.

The push bar type of elevators have blocks of wood or bars attached to one or more strands of chains which run over end sprockets. The double-strand roller chain design is an improved type. Motion is given to the packages by the pushing or dragging action of the bars. For handling heavy objects a runway bed of steel or wood rollers facilitates their travel and reduces the drag on the machine. This type is extensively used in light manufacturing operations, but it is not well adapted to handling bags, loose bundles, or unsymmetrical packages. Its chief

advantages are simplicity of operation, low first cost, and ease of automatic loading. It may be inclined at angles of 60 to 75 degrees, and has a capacity range from 500 to 1,200 packages per hour at chain speed of 60 to 90 feet per minute.

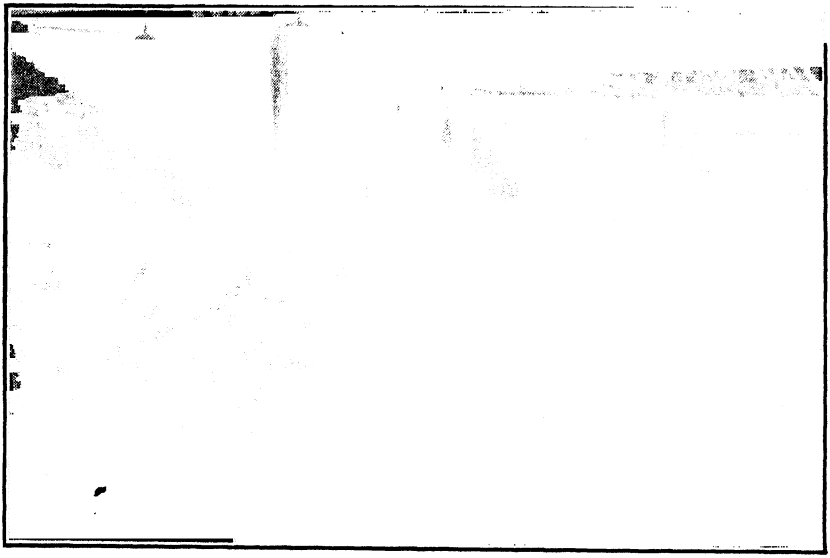
Trucking Equipment.—This includes hand trucks, three- and four-wheel platform trucks, hand lift trucks, power trucks, power lift trucks, crane trucks, tractors and trailers, and industrial railways. Accompanying illustrations show a number of these in use.



(Courtesy of Stuebing-Cowan Co.)

Figure 50. Heavy Loads, Stacked High, Are Handled Cheaply by Hand Lift Trucks

For short movements of parcel freight hand trucks cannot be dispensed with. The two-wheel type are designed to pick up, move, and drop loads with a minimum of effort on the part of the operator, and to work in areas too small to admit larger equipment. Three- and four-



(Courtesy of Automatic Transportation Co.)

Figure 51. Handling Wire on Metal Skid with Lift Truck

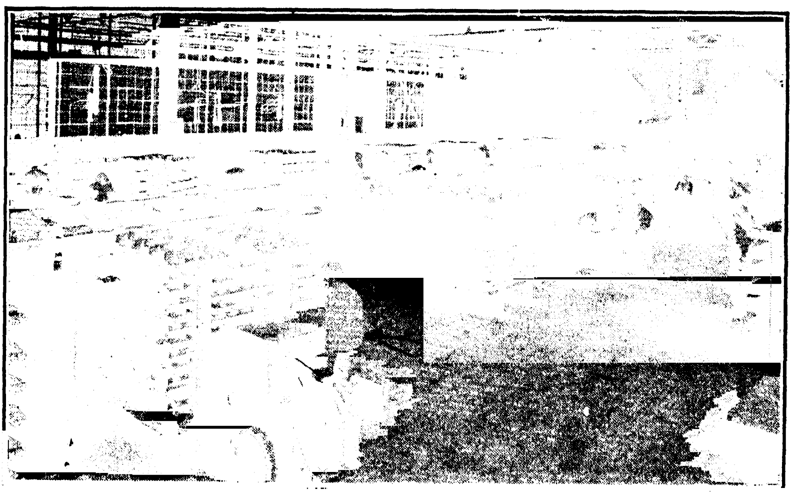
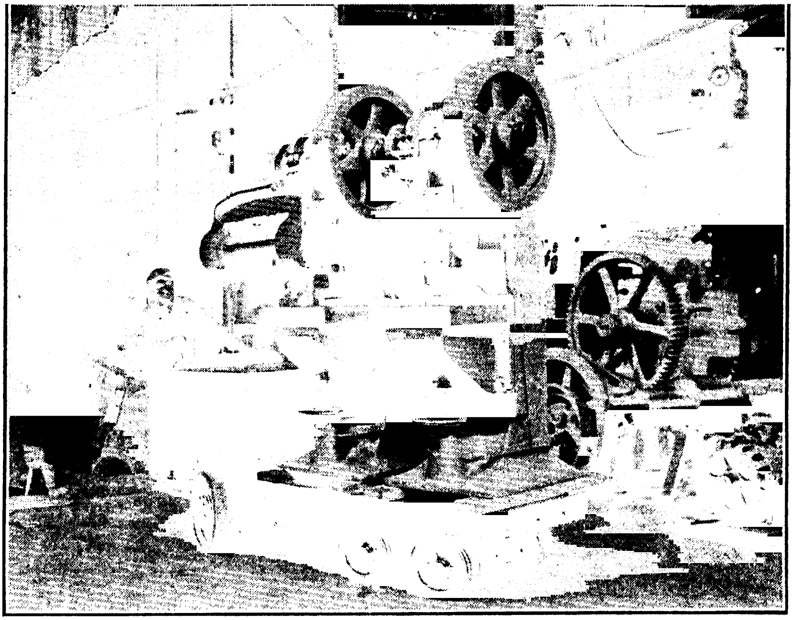


Figure 52. Lift Trucks Used to Move Core Racks to and from Core Ovens

wheel trucks are of almost infinite design, and may be suited very accurately to any need. One manufacturer advertises more than 300 standard and special designs. They may be of the box, rack, or platform type. Low investment and operation costs make operating charges little more than one cent a day.



(Courtesy of Elwell-Parker Electric Co.)

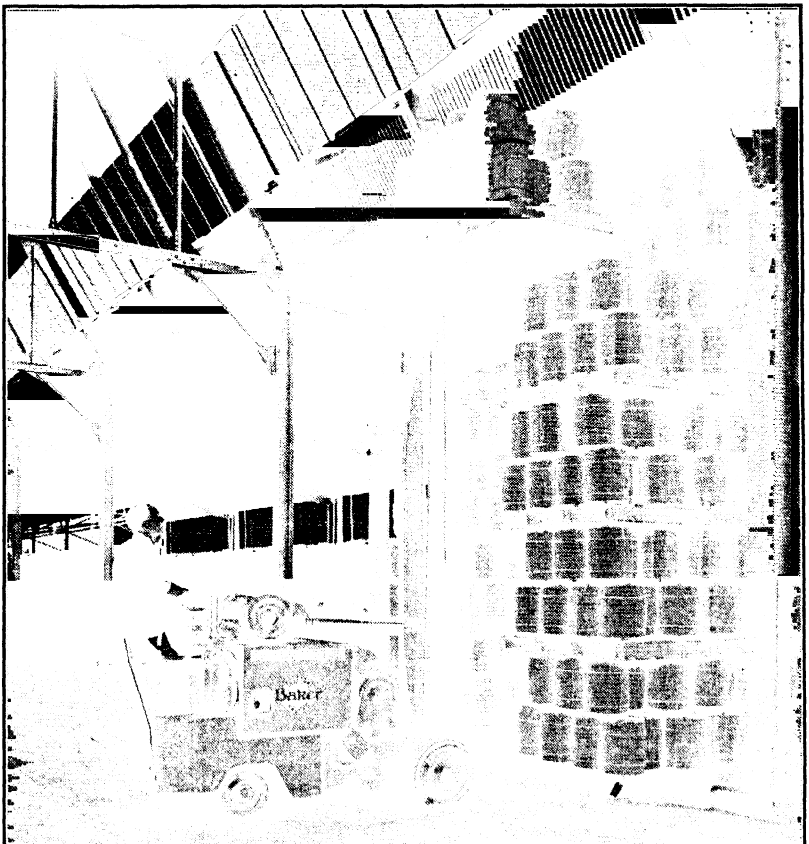
Figure 53. A Ten-Ton Load of Machines. Thirty-Ton Loads May Be Handled with This Type of Equipment

Lift Trucks.—The use of lift trucks makes it possible to move goods and avoid rehandling by using movable platforms or skids. As two-thirds or more of the time spent in handling materials is often used in loading and unloading, this possible saving is important. The hand-operated lift truck is used for short hauls and a small volume of handling where the extra cost of power lift truck service is not warranted. Material may be piled as high as ordinarily feasible in storage, and loads of two tons or more may be readily moved. As the full platform area of trucks may be used, there is no waste space.

One man with a lift truck will perform five times as much work as a man with an ordinary truck. Roller bearing equipment makes big loads possible. When not in use, the movable platforms can be stacked, thus conserving floor space. Standard practice in many plants is to place

goods as received upon movable platforms, and thus avoid all rehandling up to the point of use. In some lines suppliers find it advantageous to deliver materials such as paper stocks, sheet steel, and heavy machines on platforms or skids which can be handled by lift trucks. This is an economy to buyer and seller alike.

Tiering Trucks—Crane Trucks—Tractors and Trailers.—Elevating or tiering trucks are of great convenience in stacking articles or removing material from shelves. The lifting platform may be similar to that of the usual lift truck, but it is capable of being raised to a greater height. Such equipment aids in utilizing space, increasing storage capacity, and conserving time and man power.



(Courtesy of The Baker-Raulang Co.)

Figure 54. Tiering Trucks Pick Up, Move, and Pile their Loads

Power trucks equipped with cranes are used for picking up and transporting heavy articles. They are more flexible in use than man power, and possess much greater strength. Loads of 6,000 pounds may be lifted and moved at speeds as high as 15 miles per hour.

Tractors and trailers will handle material at less cost per ton than power trucks. Though they lack the extreme individual flexibility found in the latter, their maintenance and operating costs are less since one power unit pulls many detachable trailers. The tractor-trailer system (1) increases the hauling capacity of the power unit, (2) reduces moving costs, (3) saves the time of truck or tractor while loading or unloading takes place, (4) moves objects that cannot be handled on trucks alone, and (5) accommodates itself readily to varying demands for service.

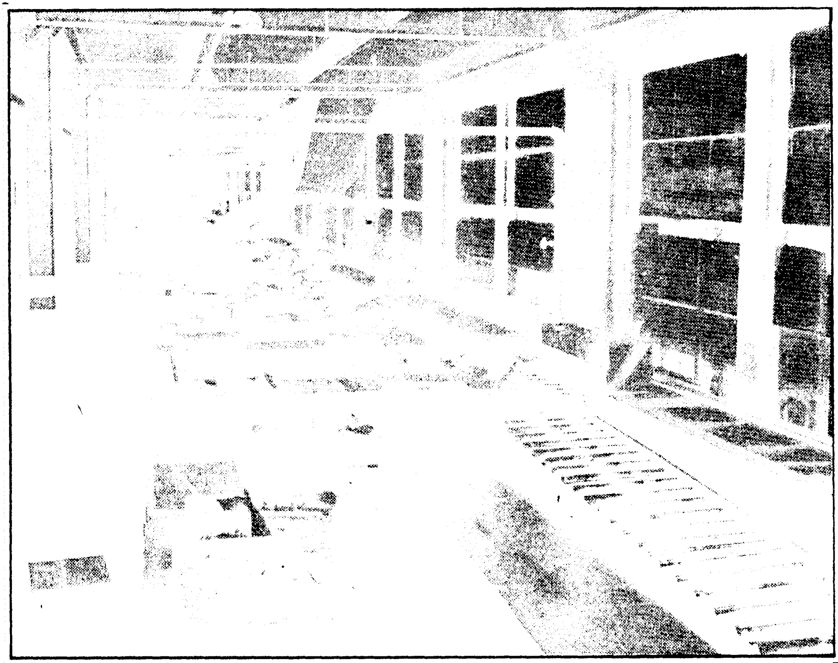
Conveyors.—Modern materials handling has made extensive use of conveyors of all kinds. They are adapted to use in shipping rooms, foundries, bottling plants, machine shops, and assembly lines. In fact, they have almost universal application when transportation is to be made along a fixed route and for not too long a distance. Mass production could scarcely exist without the many types of conveyors it employs not only to move materials but to facilitate processing. Belt, apron, roller, and chain conveyors are commonly employed for this purpose, but there are many other types as well.

Belt conveyors usually consist of an endless fabric belt, on which material is placed and which travels over idlers spaced at intervals. The belt may be formed into a trough shape by using special idlers. This type is used for moving many products, including both bulk materials and light or fairly heavy unit parts. The continuous surface of the belt adapts it to packages of even the smallest size. By utilizing the return run of the belt, containers or articles may be moved in a reverse direction, but this is not common. Power requirements for belt conveyors are small, the equipment is smooth and noiseless in operation, has great carrying capacity, and loading or unloading is readily effected at any point. The belt fabric is subject to wear, however, and must be replaced more or less frequently. Belt conveyors are run successfully on an upgrade. By attaching to the belt cleats or arms it is possible to move fairly heavy packages up steep inclines. Flat belt conveyors of stainless steel are in use and contribute to sanitation in the handling of food products.

Apron or platform conveyors usually consist of one or two chains to which wood or metal slats are attached, so as to form a continuous apron or platform, which supports and carries the load. Pan conveyors are similar to the apron type, except that they have pans of considerable

width for a carrying medium. The capacity of these types is lower than that of belt conveyors on account of necessary differences in operating speed, but they are more durable.

Installations of roller conveyor systems are very common. Practically any object may be handled either directly on the rollers or in trays. When set at very slight inclines gravity action is sufficient to move



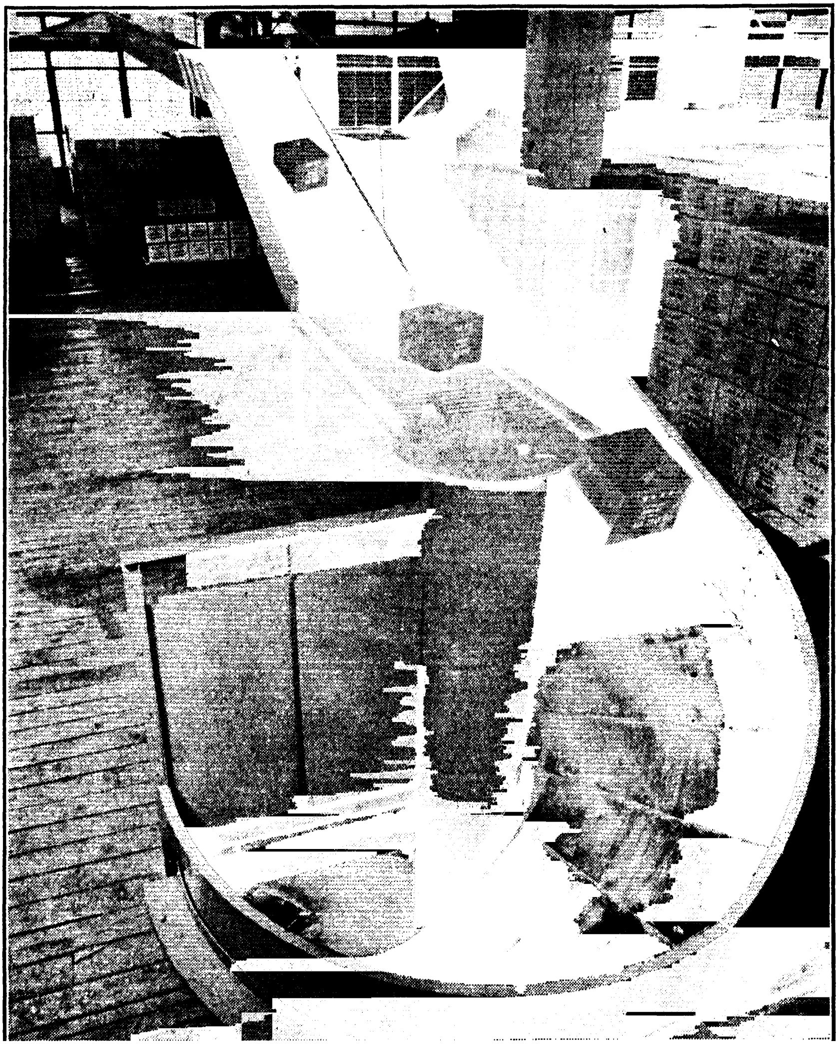
(Courtesy of The Lamson Co.)

Figure 55. Orders Are Carried to Packers on Belt Conveyor at Right

Loads are deflected to roller conveyor sections by electric controls. The platform conveyor at left takes boxes to shipping department.

goods, and where needed power sections may be used. The use of booster sections to elevate goods to upper stories has greatly extended the scope of gravity handling. In some large buildings this type of equipment, combined with roller spirals, is depended upon for all conveying service. Portable sections used from stock piles to the main conveyor, and vice versa, add greatly to the flexibility of the system. The equipment is simple, compact, and of rugged construction.

Spiral conveyors of the chute and roller type are designed to handle unit products in vertical direction and often as connecting links in hori-



(Courtesy of The Lamson Co.)

Figure 56. Conveyor Equipment Leading to Spiral Chute

zontal systems. When goods are finished on upper floors they are economically delivered by means of this type of equipment to machines, into stores or waiting cars below. The gravity roller spiral offers an economical means of lowering packages which must be handled with care. Any package which will travel on a gravity roller conveyor can be lowered directly on the rollers, while the use of pallets, trays, or tote boxes permits the successful handling of small parts and irregular objects. This makes a roller spiral specially applicable to manufacturing purposes. Gravity roller spirals can be used as temporary storage for fragile products since they will start or come to rest easily and evenly on the roller runways.

The conveying capacity of the roller spiral is practically unlimited, depending only on the grade at which the runway is set. For such packages as barrels on end, filled tote boxes, or trays with easily disarranged contents, the roller runway is more satisfactory than the friction spiral. It occupies more space than the latter, but affords more storage space. Another advantage is the absence of wear on baskets and containers used to carry goods.

Screw conveyors consist of a half-round or enclosed trough in which a spiral blade rotates about a center shaft pushing the material along. They are used extensively for handling grains, flour, cement, and similar materials.

Pneumatic conveyors are particularly adapted for handling grains, cotton or other bulk materials which are not sticky or fragile. Shoveling, rehandling waste, spillage, and contamination are eliminated. Suction inlets may be of the hose type which can be moved about and into corners, and the pipe lines are run in out-of-the-way places or overhead. Air is used to move materials economically from 25 to 2,000 feet. In some instances this possibility will overcome the handicap of poor departmental arrangements in existing plants. For liquids, pipe lines are used, operating by gravity or under pressure.

Assembly Line Conveyors.—Conveyors used for assembly lines are not essentially different from those described, and may be the same. Adaptations of the various types to fit specific requirements are often effected. Figure 57 shows a two-strand chain type of conveyor with wheels running on rails. Mounted on the chain are seats to hold the machinery being assembled. Unduly long assembly lines are avoided by providing short parallel lines for unit assemblies.

Overhead Conveying.—Overhead rail systems carry parts or unit assemblies from one operation or assembly to another. Overhead systems

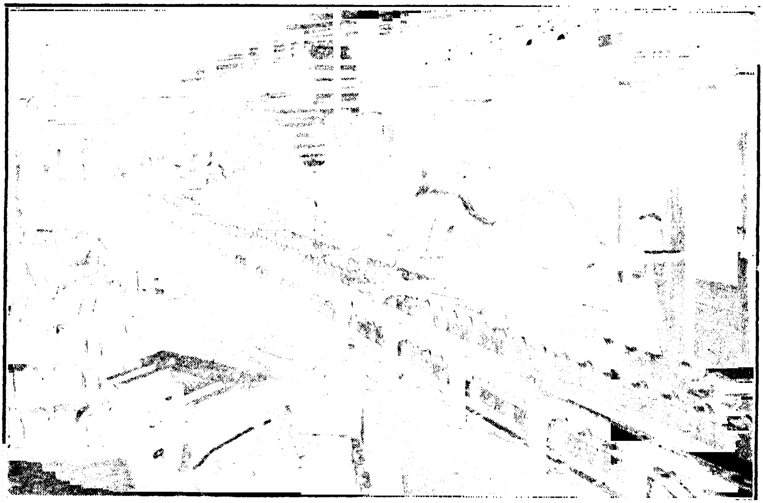
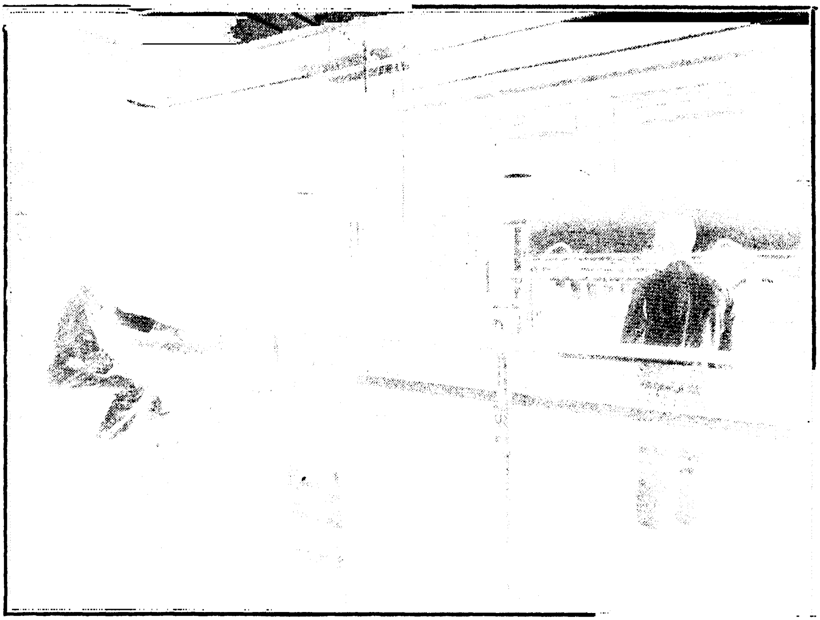


Figure 57. Tractor Assembly Line

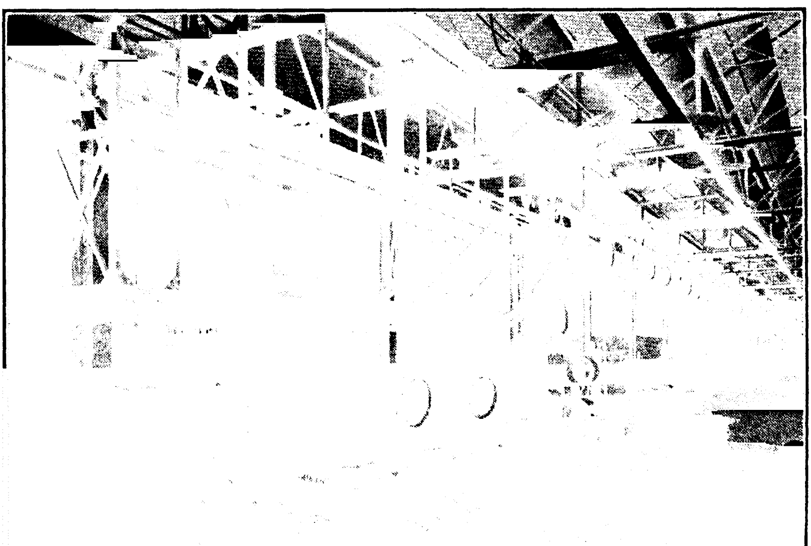
(Courtesy of Gifford-Wood Co.)

Figure 58. A Bar Attached to the Chain Moves the Skids as Desired
Heat treating may be accomplished as a continuous operation.



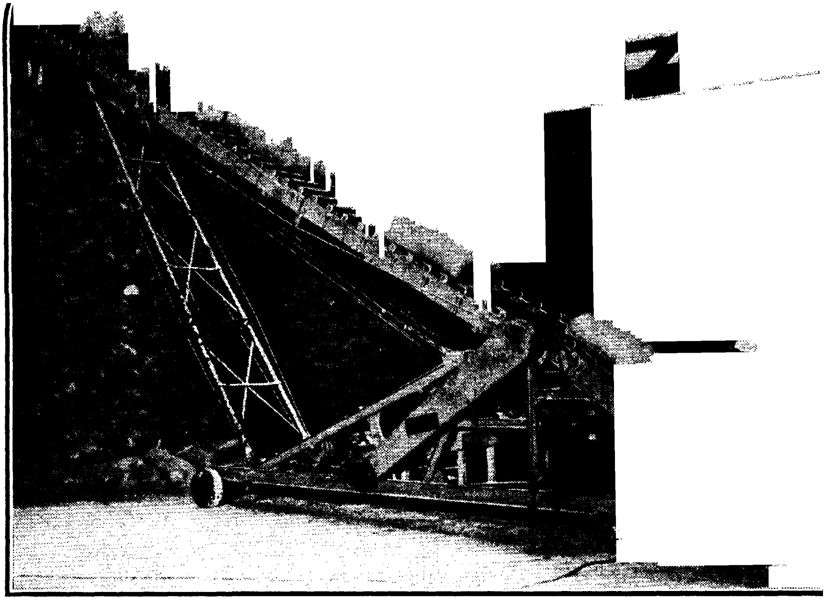
(Courtesy of General Electric Vapor Lamp Co.)

Figure 59. Conveyors Coordinate Washing, Sterilizing, Inspection and Bottling Operations



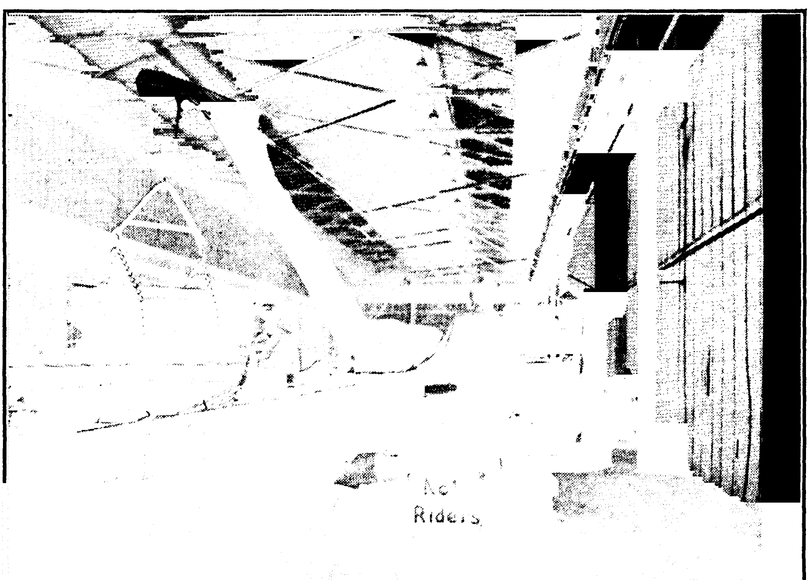
(Courtesy of The Lamson Co.)

Figure 60. Power Operated Chain Overhead Conveyor Delivering Wheels to Truck Assembly



(Courtesy of Standard Conveyor Co.)

Figure 61. A Portable, Combination Piler Stacking Sacks in a Large Sugar Refinery



(Courtesy of Automatic Transportation Co.)

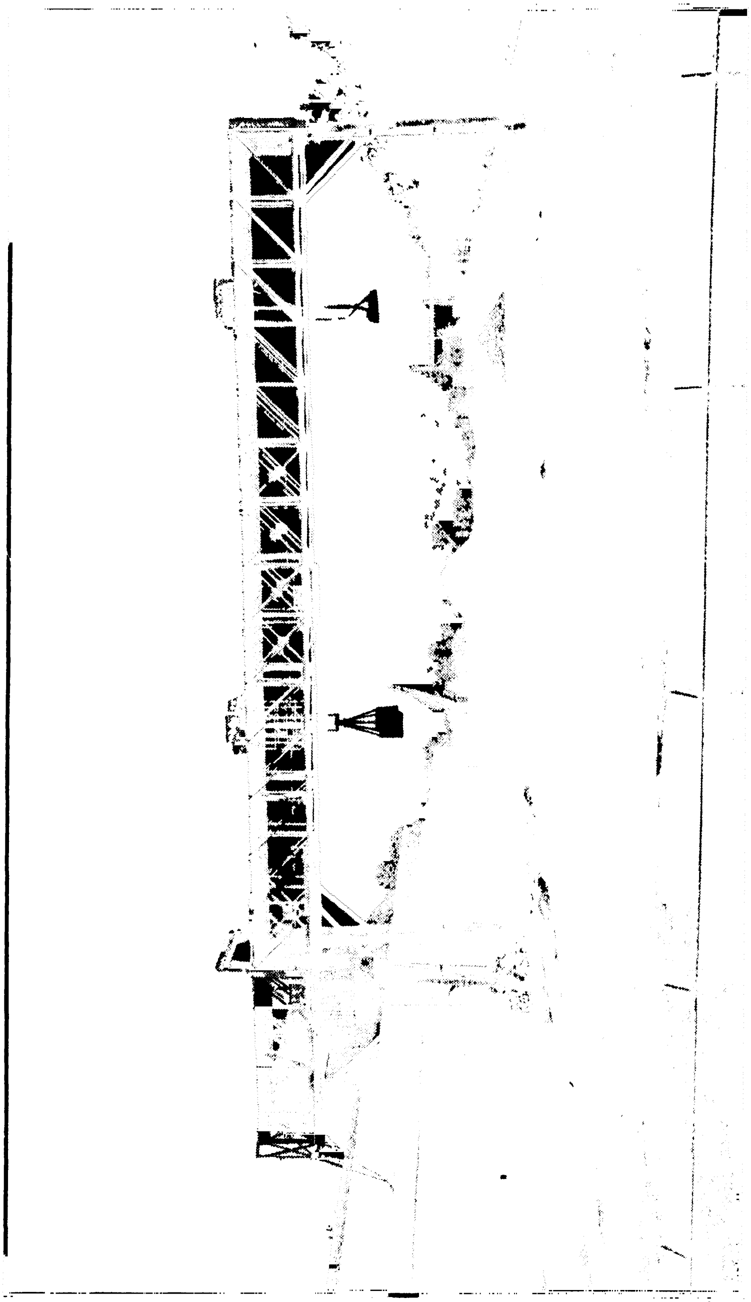
Figure 62. A Crane Truck Which Performs a Variety of Handling and Transport Work

of conveying have the merit of keeping traffic off the floor, and providing continuous, large capacity equipment which handles products without danger of damage. Man power is also saved. The idea was probably first used extensively in the packing houses, where carcasses are handled through production, into storage and later into cars this way. When dipping operations are to be performed a section of track is designed to be lowered and raised. Many assembly, finishing, painting, and baking operations may be performed on articles suspended from overhead hangers. Monorails equipped with traveling cage hoists provide a versatile pick-up and moving service.

Cranes.—Cranes allow for three dimensional movement of materials, a feature which is essential in many operations. Common types are the jib, overhead, and gantry. Figure 42 pictures a jib crane in a machine shop. While the area served is limited, the areas of service for adjacent cranes can be made to overlap sufficiently, so that with this type of equipment a heavy part can be moved through a sequence of operations and placed in working positions at successive machines. In the example shown a load picked up by the chain block hoist can be moved vertically, and as the boom may be swung through a half-circle, the load may be placed at any point within the area. Air or electric hoists can be used as a part of the equipment.

Overhead cranes are as varied in design as the need for them, and combine different degrees and types of mechanical operation. Some are operated from the floor, have hand-operated hoisting equipment, and are moved longitudinally by pushing the load. Other designs range from the single girder of short span, equipped with a simple chain or electric hoist for comparatively light handling, to the multiple girder type equipped with electric hoists capable of raising 100 or more tons. Installed on elevated runways, cranes permit the use of all floor space for storage or manufacturing purposes, and having both transverse and longitudinal motion, they reach all points of the floor area. Figures 44 and 45 illustrate the effective use of bridge type cranes.

Gantry cranes are an adaptation of the overhead type of crane for outdoor service. The crane bridge is fixed on trestles having legs which are generally mounted on trucks similar to those used on overhead traveling cranes. The whole structure moves on rails at the ground level. The crane is then known as a traveling gantry. To meet special operating conditions they are sometimes constructed with one gantry leg—the other end of the bridge being supported by other means; with a single or double cantilever bridge; or with a movable cantilever at one end. Gantry cranes are made with a span upward to 200 feet or more. They



(Courtesy of Whiting Corp.)

Figure 63. A Gantry Crane in Storage Yard

are used in storage yards, and extensively in shipyards for erecting purposes and for ship fitting work.

Analyzing Comparative Handling Costs.—Reports analyzing comparative handling costs between different types of equipment should be prepared with great care and thoroughness. Besides investigating the amount of work which each type can accomplish and the direct expenses incident to operation, several indirect costs may also be incurred. These include (1) value of production lost during installation, (2) loss of value of equipment previously in use, (3) differences in investment, insurance, tax, depreciation and obsolescence charges, (4) effect on breakage, (5) accident hazard, (6) use of floor space, and (7) building alteration and maintenance charges.

Because the cost for mechanical handling equipment is oftentimes considerable, the returns should be substantial. Depreciation, obsolescence, and changed manufacturing conditions are factors which greatly affect the value of this kind of equipment. The majority of investors expect to have a full return within one, two, or three years' time; some are content to wait a year or two longer. General rules will not apply, however, for some forms of conveying equipment are still in operation after 25 or 30 years of satisfactory use.

Influence of Building Design.—The successful handling of materials is often a difficult task in existing buildings not particularly designed for the purpose used. If they are ten or more years old the requirements of modern handling methods in structural design and arrangements will probably not have been anticipated. Elevators may not be located in strategic places, nor floor systems designed to sustain the shock loads imposed by heavily loaded trucks. Few old buildings have ramp truckways from floor to floor. The installation of overhead equipment, such as cranes, monorails, and hoists, requires carrying power in trusses, columns, and ceilings that will likely be lacking. Conveyor lines through floors are not always feasible, because of the existing construction. The cost of cutting reinforced concrete floors is a very considerable item, even if it is possible without seriously weakening the structure. The same objection exists to the installation of elevators, spiral conveyors, and chutes; and the fire hazard introduced must be guarded against. Flexibility in original design and anticipation of future possible requirements add to original costs, but they pay in the long run.

Organization for Handling.—Plants with extensive handling problems and a great deal of equipment find it pays to employ a superin-

tendent of traffic. In medium-sized and small plants responsibility should be centered in one individual, who may devote part of his time if not all of it to the administration and improvement of handling facilities.

In many small plants it is unnecessary to work out complete schedules for moving goods in process, or controlling equipment movements from a central station. The attention of foremen, mechanics, and move men suffices to keep products moving without unnecessary delays in natural channels. The constant check afforded by the production control system also aids in keeping materials constantly progressing toward completion. In larger plants established channels of flow are not so self-evident, and the foreman's casual attention is not sufficient.

The principal task of a transportation superintendent is to organize and use equipment effectively in prompt movement of goods. Handling demands are studied and, so far as practicable, a standard procedure and schedule are evolved for all material movements. Regular routes may be laid out, and clearing stations and transfer points designated. A central office, available by telephone, controls all movements and provides special service in case of unusual demands or contingencies. Experience shows that centralized control invariably brings operating economies and better service where the problem is extensive.

CHAPTER 14

PLANT LAYOUT

Planning the Layout.—The proper layout of a manufacturing plant is an ever-recurring problem. It entails a consideration of the arrangement of buildings, departments, workplaces, machines, lighting and ventilating equipment, and other physical features. Even before the building is constructed the layout of the production facilities should be analyzed and a decision made on the arrangement desired, for this may have a profound effect on the design and location of the buildings required. After construction has been completed and the factory has started operations, the problem of layout is not ended, for new processes, new machines and new products make it necessary to keep studying the plant arrangement to see if a better layout cannot be obtained.

To a large degree economical production depends upon skilled planning in determining the plant layout. Changing the location of machines is expensive, but if it results in operating economies the money is usually well spent. Considering the factory as a production machine, the layout of departments and their relation to each other must be right or the machine will be clumsy and awkward in operation, and consequently inefficient. Careful planning should precede the beginning of operations on new models, for that is the time when changes can be made with the least disruption in operating schedules. Often months are spent in deciding such problems, since what affects one part of production may influence many others.

Influence of Layout Upon Costs.—Manufacturing arrangements greatly influence the amount of labor effort in handling work in process, length of hauls, and consequently cost of handling; the time of work in process and its volume; expense of production control, cost of inspection and counting; investment in equipment; and space requirements.

Analysis of Manufacturing Requirements.—A study along the following lines is suggested as preliminary to final action in matters of layout and arrangement, equipment selection, and housing facilities.

1. The desired capacity of the plant, and the estimated capacity.
2. The divisions of the manufacturing schedule to determine the number and variety of the sub-assembled or finished units to be produced.

3. A list of materials or parts comprising the product to determine which ones will be manufactured and which ones purchased and stored.

4. The production equipment or plant facilities needed for the desired capacity of the initial plant, including any special provisions or structural features which will facilitate production.

5. A study of the manufacturing and assembling operations necessary to produce a finished or sub-assembled unit, to check the proper spacing of equipment.

6. The time interval required between successive operations, if any, to check the need for and location of storage space.

7. The sequence of operations in manufacturing and assembly departments in order that departments and equipment shall be in logical and convenient relationship for the progressive flow of materials.

8. The space requirements per department to house the production equipment and provide the space needed for aisles, storage or auxiliary departments.

9. A review of the various operations entering the process to determine whether certain departments should be isolated from the standpoint of safety, noise or special process needs.

10. A summary of the floor space needs of the initial plant, which areas can be proportionately increased for the different departments, based on an assumed future capacity after a certain period of years, thus providing an approximate basis for estimating the space requirements and development of a suitable layout for the ultimate plant development.[1]

Influence of Processes.—Processes determine layout, and arrangements for manufacture should be a logical expression of production process needs. Some requirements lend themselves to housing in one building, in either a single-story or multi-story structure. Printing, bookbinding, some textile and leather product plants, bakeries, candy, and hosiery plants provide examples; although in the latter the dyeing and mercerizing departments may be placed in separate units. Thus, in bleach and dye works, cloth printing establishments, and where polishing and buffing, plating, or painting and enameling departments are needed, separate housing and different building constructions may be necessary or preferable due to vapors and fumes, dust and dirt, presence of acids, or fire and explosion hazards involved. Gravity handling of materials, especially liquids, calls for multi-story buildings as in starch factories. In corn products plants, and in the metal trades industry, a number of separate buildings are usually called for because of the differences in nature of the processes carried on.

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[1] "Influence of Design on Plant Efficiency," by H. T. Moore, *Mechanical Engineering,* Vol. 47, No. 11a, pp. 1059–1060.

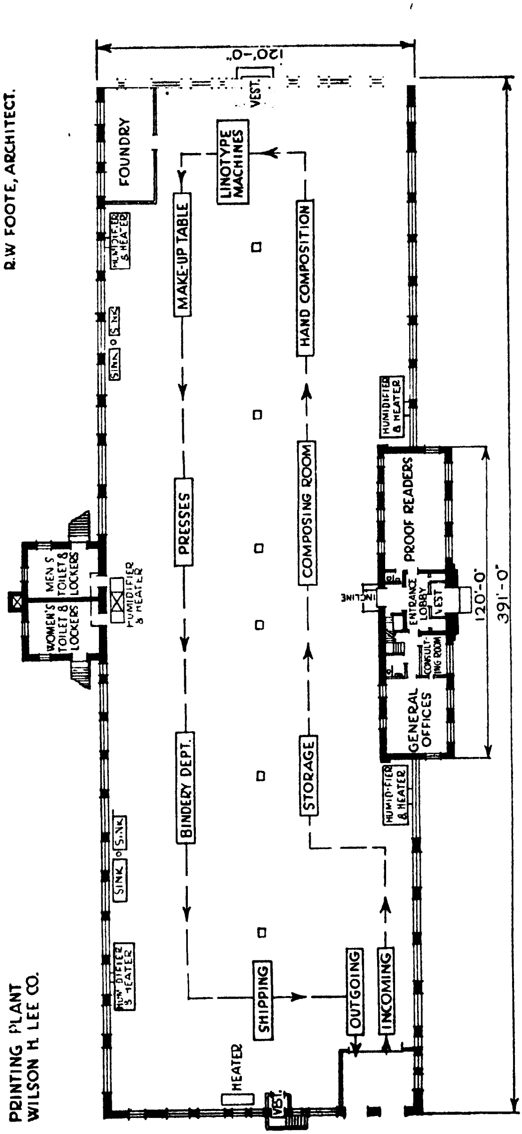


Figure 64. Flow Sheet for a Printing Plant

Flow Sheet of Processes.—A study of materials and work in process will disclose a main channel or flow of work, the departments required, and approximate areas and locations. The problem is most simple when but one product is produced, such as cement or brick; or when all items move along the same path and sequence of operations, as in a tire plant. It becomes more complicated as a variety of items are produced, with varied processing and machine requirements. In these cases it is necessary to prepare flow sheets or route charts for the more important items from the volume and handling standpoint. Departments may then be located so that the layout is most effective, all items considered, although less so for some of them. Figure 64 shows a flow sheet for a printing plant.

Preliminary findings with regard to paths of travel of materials will be subject to some necessary modifications as details are filled in, handling and manufacturing arrangements determined more definitely, and possibly to avoid impractical building constructions, or to fit into existing structures.

Machine Equipment.—In designing products and planning for their manufacture, decisions are reached with respect to operations to be performed, sequence of operations on each part, and the tools and machines to be used. For each part there will be prepared an operation list indicating operations needed, where performed, their sequence, and other necessary information. Figure 65 provides a typical manufacturing analysis of this kind. This record serves also as a master route card for the part. A summary of similar data for all parts produced with information of the time required for each operation or process will aid in determining the amount of machine equipment needed for each department. General factors to be considered are:

1. Volume of production.
2. Rated capacity of equipment.
3. Hours of work planned for.
4. Normal production capacity considering working arrangements, idle time for set-ups, repairs, scheduling of orders, etc.

It is not to be expected that a machine can be continuously operated to the theoretical rated capacity. Various considerations will prevent this. Material worked upon will vary in quality and character, tools will become dull, workmen will vary in proficiency, repairs will consume working time, and idleness at times will be inevitable due to schedules. Considerable latitude must be allowed in the choice of machine capacity. A normal capacity of 80% of the rated capacity is frequently reasonable

as a basis for scheduling work in machine departments. In the design of a jobbing plant, when the output is governed by individual specifications, an equipment schedule can only be approximated. It is then necessary to use past experience and future predictions as a basis for decisions.

A time analysis of different operations, together with the needed transportation and possibly storage time between operations, will supply

MANUFACTURING LAYOUT RECORD

DEPT.	OPERATIONS	TOOLS AND SPECIFICATIONS	MACHINES
338	Perf. (4) .093" holes and Blank	P&D C-16374.	#3 Bliss
	Tumble	Sawdust and pumice	Tumb. bbl.
	Flatten	P&D C-57827	#19 Bliss
641-2	Inspect		
263	Count		
333	Bore 53/64" hole	Jig C-2295 Use gauge pin assembly Det.#16 Gauge plate Det.#2 in pos. H. Det.#7 in position "A", and gauge pin, Det. #9 in position 1 and 8. Combination c'bore and c'sink tool C-48318, ground to suit	1 Sp. B.D.P.
	Grind off c'boring burr in	Disc C-72199	Disc. Motor
	Countersink (4) holes	Sp. Gr. Drill	1 Sp. B.D.P.
	Remove Grinding burr in 53/64" hole	Scraper	Bench
642-3	Inspect		
251	Count		
343	Acid Dip	Spec. 50029, Method #9-B	
	Dry	Spec. 50032, Method #1-A	
643-1	Inspect		
255	Count		
230	Store		

DELIVER IN CONTAINER NO. 782 UNLESS OTHERWISE SPECIFIED

ISSUE 2-19-	SHEET NO.	NAME OF PART Face Plate,	DRWG. P-88235
REPL. ISSUE 12-28.	SHEETS IN SET	APPARATUS Misc. Signals	

FROM STORE	QUANTITY PER 1000 PARTS	RAW MATERIAL NUMBERS	PART NO. OR DESCRIPTION OF STOCK	DELIVER TO DEPT.
229	35.#		1064" x 1-9/32" x 72" Grade "A" Half Hard Brass Sheet, Spec. 57504 53 pcs. per sheet 1-9/32" x 72" (On 1-11/32" centers) 18.87 - sheets 1-9/32" x 72" per M Pcs.	338

ISSUED BY PLANNING DIVISION | DO NOT REMOVE THIS LAYOUT FROM BINDER

Figure 65. A Typical Manufacturing Analysis of a Part

over-all manufacturing time. This will be less for parts moving forward a unit at a time, than for lots. Some operations require a greater length of time to complete than others and if parts are handled in lots, congestion may be caused at some points and idleness at others unless work is carefully scheduled and machine capacities provided to meet schedule demands. Figure 66 shows results of an analysis of machine times for a series of operations on a lot of 30 dozen refrigerators. Figure 67 shows the 40-hour manufacturing cycle which was planned, and indicates the balanced capacity of respective work stations. As noted, it is not necessary to await completion of an operation upon all the parts in a lot before

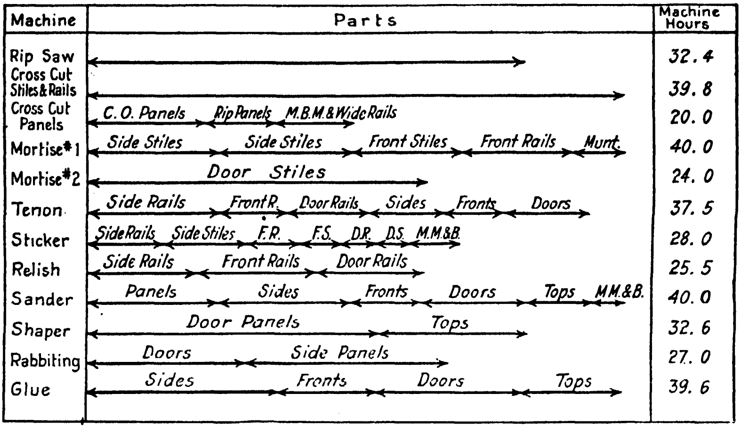


Figure 66. Machine Load Chart Showing Standard Hours Per Machine for a 30-Dozen Lot of Refrigerators

starting the succeeding operation. In order to maintain the manufacturing cycle established, the size of the lots for various models was varied. The objective was to have the same time allowance for a standard lot of any type or size.

Product designs should be analyzed by manufacturing departments before final approval, to eliminate features which would prove troublesome from a production standpoint, or add to cost.

Processes and Methods.—Industry is not static, but evolutionary. Processes and methods of accomplishment are subject to change and improvement. It is not unknown for manufacturing plants to be laid out, built, and equipped for production, utilizing certain newly discovered processes, only to be rendered almost valueless because of the discovery of yet a newer and better way for obtaining the same result.

This situation obtains more particularly in the many lines of industry involving chemical processes, which include soap making, the dye-trades, production of starch, glucose, paper, explosives, imitation leather and many other products. In many such industries there is a possible choice of processes for carrying on particular parts of the production program, and various factors will affect the selection of the one to be used. Considerations might be: (1) the quality of the output, (2) the quantity, (3) space requirements, (4) investment necessary, (5) reliability, (6) amount of labor required, (7) kind of labor, (8) ease of replacement of equipment, (9) probability of changes or improvements being effected, (10) hazard to workmen, (11) legislation, (12) smells created,

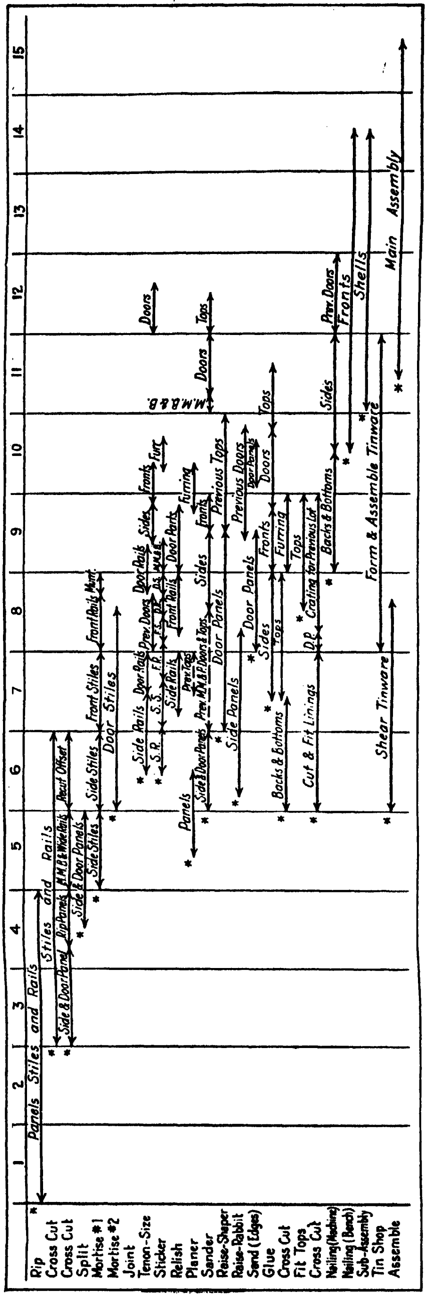


Figure 67. Graphic Schedule Showing Standard Operation Times, Sequence of Operations, and Operation Release Points for a 30-Dozen Lot of Refrigerators

(13) cost, and perhaps others. A thorough economic analysis is necessary to arrive at the correct answer in each case. In the mechanical trades improvements of machinery and equipment are constantly being made. Likewise, competition and the results of market surveys frequently suggest variations in production, and it should be possible to effect corresponding changes in layout at the least cost. Thus it will be seen that layout and equipment should be as flexible as possible.

With processes and methods decided upon, the selection of machinery and equipment for the various departments is next to be made.

Selecting the Equipment.—The wise selection of equipment requires a knowledge of the fundamentals of good engineering design; it implies a thorough familiarity with different types and kinds of equipment and experience with its use. The manufacturer is often the best judge of the equipment he needs. In larger plants a committee composed of the general manager, superintendent of production, and head of the engineering department may act. There are advantages, however, in utilizing the services of specialists if circumstances warrant. It is not unusual to have a score or more of machinery and equipment companies competing when even a moderate size plant is to be equipped. It takes time to hear these many appeals, and considerable expertness to evaluate accurately their various claims.

Consulting engineers in this field bring to bear upon specific problems a wealth of experience gained throughout a wide range of industry. They have had opportunity to study equipment and machinery in operation under varying conditions. They act as a clearing house for the best practice which has been evolved. Thoroughly grounded in the principles of machine design and experienced in its operation, they are capable of impartially and expertly analyzing sales appeals. It may be that the best solution will combine equipment from several competing concerns, and necessitate some original design to eliminate misfits, overlaps, or gaps in the layout. This phase of the task calls for real ingenuity and intelligence on the part of the engineers.

Mass production of a unit may permit the design of integrated and specialized manufacturing facilities in their entirety. Considering the product as designed, equipment engineers proceed to design special machines, tools, and conveying equipment needed to produce the unit most expeditiously and economically. This is a complete reversal of the customary way of fitting production to the shop. It is feasible only when the complete cost of the installation can be charged to the product over a relatively short period. In the automotive field this practice has resulted in some notable economies and low cost production.

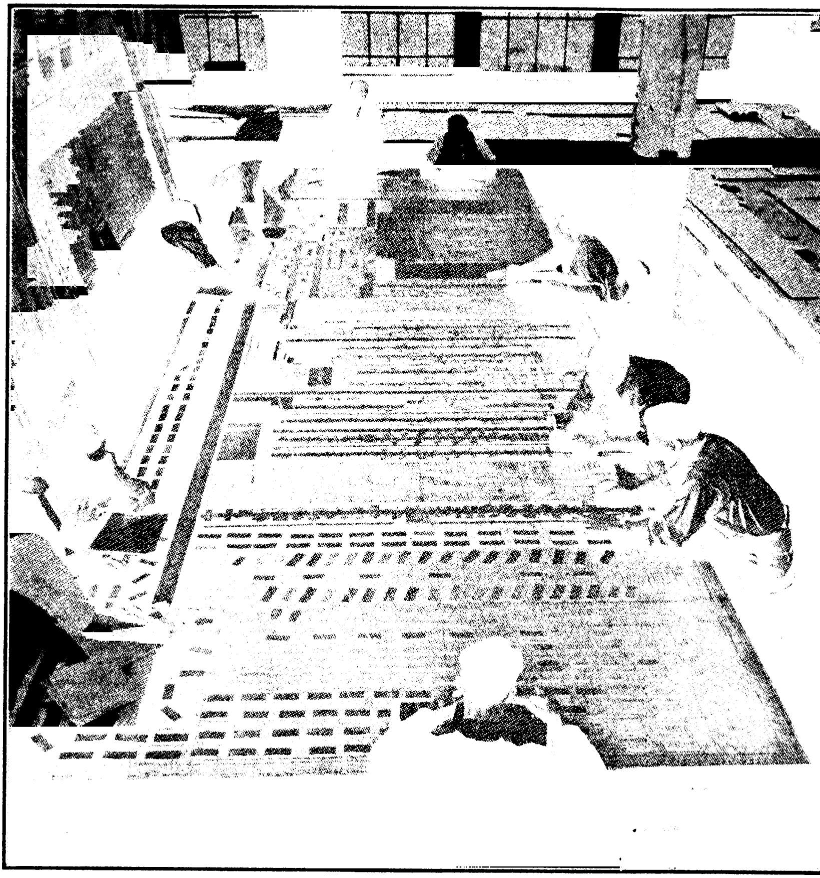
Departmental and Machine Arrangement.—Each machine must be provided with a working area and placed in proper relation to other machines. Items influencing space requirements for a machine would include its size, operating area necessary, and space needed for storage. Auxiliary equipment for effecting repairs, and questions of lighting, air conditioning, and convenience may also be considered.

The relation of departments to one another, and the grouping of individual machines should be such that the flow of materials through the plant will be as nearly as possible in a straight line.[2] This statement may be received as the repetition of a time-worn phrase and its import not realized. The majority of plants are not so arranged, even though this is an axiom in plant layout, and the observance of the principle is essential to economical, orderly manufacture.

Visualizing the Layout.—Helpful in accomplishing this is the practice of using small pieces of cardboard or templates cut to scale to represent machines. These can be placed upon a drawing or blueprint of the plant made to the same scale as the templates, and the actual conditions as they will be in the proposed form fairly well pictured. The use of small wooden models of machines made by a pattern maker serve even better in helping to visualize what actual working conditions will be like. With this equipment various arrangements can be experimented with, using colored strings or lines upon the drawing to show the path of different materials or parts, first to the various machines within a department, and second, throughout the plant. The relative volume of material, parts or goods of a kind can be indicated by using a varying number of the particular color of strings used to represent it, or by the width of line made upon the drawing. Proper location of stores and tool rooms may be readily ascertained in this same manner.

Figure 68 shows the layout chart of a large automobile plant being worked over by layout men and production experts in preparation for the introduction of a new model and the installation of new equipment. When the final arrangement is decided upon by moving the templates to the desired positions, similar changes will be made on the master map of the plant which hangs on the wall in the office of the Production Manager. The Production Manager's map shows the actual arrangement of the departments and machines as it exists, while the chart illustrated on the large table serves as a means of visualizing possible changes. Figure 69 shows a scale model constructed when the plans for a new

[2] The term "straight line," as applied to production, is interpreted to mean movements which do not involve back-tracking, or crossing of line of travel of the product.



(Courtesy Automobile Manufacturers' Assn.)

Figure 68. Studying Layout Problems in an Automobile Plant With the Help of Templates

building were being considered by the *Chicago Tribune*. All machines, presses and paper handling equipment are shown in detail. The floors of such models are usually made removable so that careful study can be made of any section.

Kinds of Manufacturing.—Four types of manufacturing plants may be noted. These are (1) job manufacturing, (2) semi-standard manufacturing, (3) standard manufacturing, and (4) continuous process production. This classification is based on the variety of products manufactured and the arrangements of equipment employed.

Figure 69. Scale Model Used to Forestall Kinks in Production, in the Plant Layout of the *Chicago Tribune*

Less than one hundred years ago practically all manufacturing plants were able to produce a large variety of products, often made up entirely to customers' specifications. Even the products made for sale had no standard design or specifications. This kind of manufacturing is known as jobbing, since almost any kind of work for which the plant is equipped will be undertaken. Many such plants exist today. Examples are: machine shops, custom tailors, certain printing plants, ship building yards, and many of the steel mills—particularly those which are engaged in bridge building.

When a company produces products of its own specifications in whole or in part but maintains a considerable variety in its line it is engaged in semi-standard manufacturing. It is the first step taken away from job manufacturing. Some examples of this class are: suit and dress manufacturers, furniture plants, textile mills, elevator companies, and machine tool companies. Often the products are finished in the same way to a certain stage and then completed later to the special requirements. At times jobbing contracts are also taken.

Standard manufacturing is producing entirely according to the company's specifications a major product with only minor model variations. Manufacturing becomes much easier and many economies can be obtained. Automobile companies, electric refrigerator manufacturers, radio and telephone companies are examples of firms of this class. Frequently a large company will manufacture several different lines but because of the quantity produced by each it can employ the machine arrangement and production techniques of standard manufacturing in each case.

Continuous process production is the final step in manufacturing beyond which we cannot go. In this case a continuous flow is maintained from the raw materials to the finished product. The whole process is practically automatic and cannot be stopped at any point without spoilage of the product, or at least a great inconvenience to the plant. Oil refineries, continuous strip steel mills, cement mills, flour mills, rayon plants, and some of the large modern bakeries have developed continuous processes. Paper mills and a large group of chemical plants also employ this type of manufacturing.

Integrated Manufacture.—Manufacturing progress has witnessed the evolution and perfection of the individual machine and the development of automatic machines. As a consequence of attention to machine development the cost of performing machine operations has been greatly decreased and manufacturing possibilities increased. Attention later turned to mechanical transportation and the integration of all productive

processes as holding further possibilities for reducing costs. This step has been largely employed in the automobile industry.

J. H. Van Deventer, in describing Ford principles and practices, says:

> The process of integrated manufacture is that in which the raw materials, product parts and even the product itself, in successive stages of completion, flow through the plant in continuous, steady streams, mechanically impelled and correctly timed.

It is the technique of mass production and may be utilized in some standard manufacturing and all continuous process production. Where the nature of the product, as in the automobile industry, does not allow complete continuous process production, integrated manufacture is as close to automatic operation as can be secured.

Grouping of Machines.—According to the type of manufacturing engaged in, the arrangement of machines will preferably be either according to the manufacturing process employed or according to the product produced. When the machines are grouped by kind or processes performed the same type of equipment is placed in one department. This is the functional or departmental plan, and is adapted to the production of a great variety of products. When one product is made in sufficiently large quantities much movement of materials may be saved and other operating economies realized by arranging the machines in line to produce this particular article. This is the so-called straight-line arrangement. In order to have straight-line production it is not necessary to have all the equipment arranged in a geometrical straight line; what is required is that the materials and parts move from process to process in as direct a manner as possible. The sub-assembly and final assembly lines in an automobile plant illustrate this.

Some plants use a combination of these two types of machine grouping, having straight-line arrangement in one or more departments to produce certain products while the rest of the plant has the machines grouped functionally. The system employed depends upon a consideration of the type of product, the quantity manufactured and other questions. Some of these are discussed in the following pages.

Mass Production.—Mass production suggests straight-line production, or completion of a unit in one department or area. It is sometimes termed unit manufacture. Parts in process usually move forward from one operation to the next a unit at a time and in a continuous stream, but not necessarily so. As an example, a manufacturing layout comprising several lines of production may contribute completed units to minor

assembly points, and to the final assembly line. For straight-line production necessary machines are arranged along a natural path of travel of materials or parts, so that each operation is performed in its natural sequence as the parts move forward. Thus, machines of a kind such as drill presses may be placed at more than one point in lines, and in the number required at each point to keep production moving and avoid congestion. A line would ordinarily work on one product, or one kind of product only. A production area can be established to handle all of a given class of work, such as crankshafts, gears, heavy castings, light castings, and the like, with several lines in each. With this plan any special or costly machines needed for the particular class of work, but not used continuously in any one line, are made accessible.

Mass production of small products composed of numerous machine made parts is possible with a modification of the above arrangement. For example, a production area may be encircled or otherwise served by a belt conveyor or powered roller conveyor having spurs branching out at functional work stations. The conveyor is used to carry pans of piece parts from the raw materials station, and from machine to machine, during their fabrication and finishing, and after completion to their respective assembly benches. Work can be put on at any spur and keyed so as to be deflected from the conveyor automatically when wanted at the spur adjacent to the work station where the next operation will be performed, though this is at the opposite end of the area. The spurs serving the machines are double-decked, the lower deck being for incoming and the upper for outgoing work. The conveyor serves as a moving storage area as well as a system of transportation. With this arrangement a functional grouping of machines and operations is permitted; that is, drill presses are grouped together, as are punch presses, automatic screw machines, and the like, with no disadvantage as to time or distance in getting parts from one operation to another. Thus there is no disadvantage in producing a variety of parts, each with its individuality as to operations required and their sequence. Straight-line or unit production layouts have advantages as follows:

1. For work which requires special equipment.
2. When outputs are large enough to keep line busy.
3. Ease of schedule and production control.
4. Elimination of interdepartmental difficulties.
5. Reduces the handling and moving of materials.
6. Less volume of work in process.
7. Saving of time in process.
8. Requires less floor space.

9. Less counting, inspection and clerical work.
10. Less damage in handling.
11. Centralized supervision and responsibility.
12. Better understanding and interest of workers.
13. For very heavy or bulky products.

In a particular case the following benefits were realized from a unit production layout:

Items	Saving in Per Cent
Raw material and process stock investment	50
Piece part investment	70
Floor space	20
Manufacturing interval	87
Production control forms and paper work	90

In addition, gains were effected in investment in equipment, in counting and inspection operations, and in spoilage costs.

Col. George D. Babcock, formerly production executive of the Caterpillar Manufacturing Co., has the following to say relative to a production layout arranged for straight-line manufacture:

A close approach can be made to the ideal if the material enters at one end of a shop, moves in a straight line for the first operation, and thence straight through the various machines to the final operation. . . . There must be no retrograde movement for any machine operation.

Certain rows, for instance, contain first some radial drills, next some horizontal machines, then some radial drills, next some horizontal boring machines, followed by another group of radial drills and then by some more boring machines. These same types of tools appear in different sequences in other parts of the shop. This arrangement was dictated by the sequence of operations, on the parts that are machined in these bays. It is too frequently assumed in most shops that moving machinery is too formidable a job to be attempted, and the work is routed to fit the shop, rather than the shop adapted to fit the work. That this is a fallacy will be realized when it is considered that for a standard line of product, the machine movement occurs but once, while the unnecessary movement of material is a constant and continuous expense. The loss due to this unnecessary movement will usually be far greater than the cost of rearranging the machinery.

It is of course, not always possible to realize the ideal of straight line movement of material. Only where the product is in such volume that all men and machines in a production line can be kept busy, will the expense of the equipment necessary be justified. Hence, while as large a proportion of the work as possible was routed through groups of machines, a considerable portion of the equipment was departmentalized, and part of the work was

routed to departments. This involved some retrogression, but a constant effort was made to bring this to a minimum.

Job Production.—For job production or manufacture of a variety of products in relatively small quantities, a functional arrangement of machines or departments will be best. Many firms make 10,000 different piece parts in widely varying quantities; others as many as 100,000 or more piece parts, some of which may be produced in small volume, but others by the millions. These are combined into a considerably lesser number of sales products. Those products sold in sufficient volume will justify mass production arrangements, but the others will more logically be produced with a functional set-up of machinery. The advantages of departmental grouping of machines by kind are in general as follows:

1. A high degree of flexibility as regards parts worked upon.
2. Maximum machine activity and usefulness.
3. Minimum duplication of equipment.
4. Higher degrees of proficiency achieved by operators as a result of group specialization.
5. More skilled supervision.
6. Minimizes problem of training labor.
7. Promotes development in each line of manufacturing activity.
8. Generally a greater precision of work possible.

Obvious disadvantages are increased handling, inspection, counting, production control, and the task of coordinating department efforts.

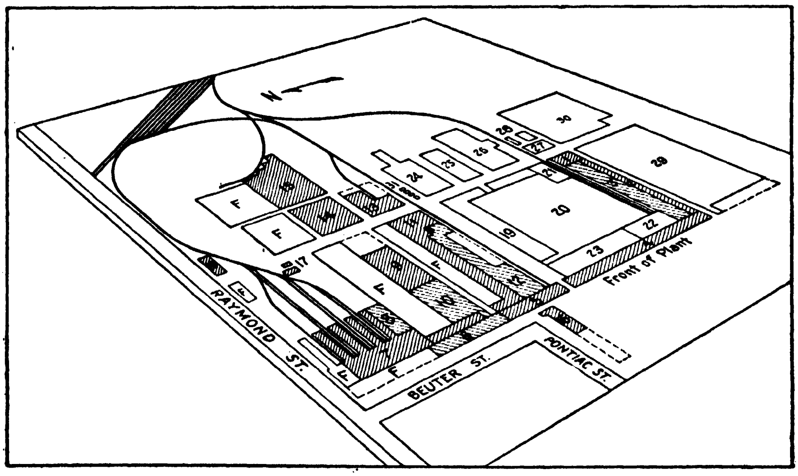
Shortening Production Time.—Increased use of power trucks and conveying equipment has minimized the time element in moving goods, even when considerable distance has to be covered.

In studying the flow of production it is well to know the total time which elapses between starting material in work and completing it, to know the total of actual time it is being worked upon as compared with the total time which elapses between operations. In some lines of manufacturing the time spent in actually doing work on material is but 15% of the total time required to complete the product, while the cost of handling between operations is from 5% to 80% of the production labor cost.

By means of well-balanced production equipment, simple routing, and minimum economical handling of material in work certain advantages accrue. It is possible to shorten the production period with the result of a smaller investment in materials, a shorter period between the buying of raw material and its sale as finished product, less indirect expense,

decreased supervision and tracing of orders, a greater plant capacity, increased service to customers, and other less obvious advantages. Remarkable cost reductions are being effected by reducing over-all manufacturing time from days to hours.

An Auto Truck Plant Layout.—Figure 70 shows areas and arrangement of departments as determined by a production analysis of the manufacture of auto trucks. Space and manufacturing requirements were carefully worked out from a study of operations and the future anticipated. The blank spaces indicate areas reserved for a logical expansion of department areas as increased production is called for in the future. With such a procedure there is little chance for abnormal, uneconomical growth.



(Courtesy of Day & Zimmerman, Inc.)

Figure 70. Truck Plant Layout

Continuous Process Production.—In flour mills, cement mills, starch factories, smelters and paper mills raw material enters the machinery at one end and emerges at the opposite end as finished product or products. If the process results in more than one finished product from one raw material it is termed analytical. If several raw materials enter into the forming of one finished product, it is termed synthetical.

In either of these forms of production the machinery operates as a unit, and the material is automatically carried from one process to another to completion. The proper selection and design of such equipment solves all problems of routing, transportation, departmentalization,

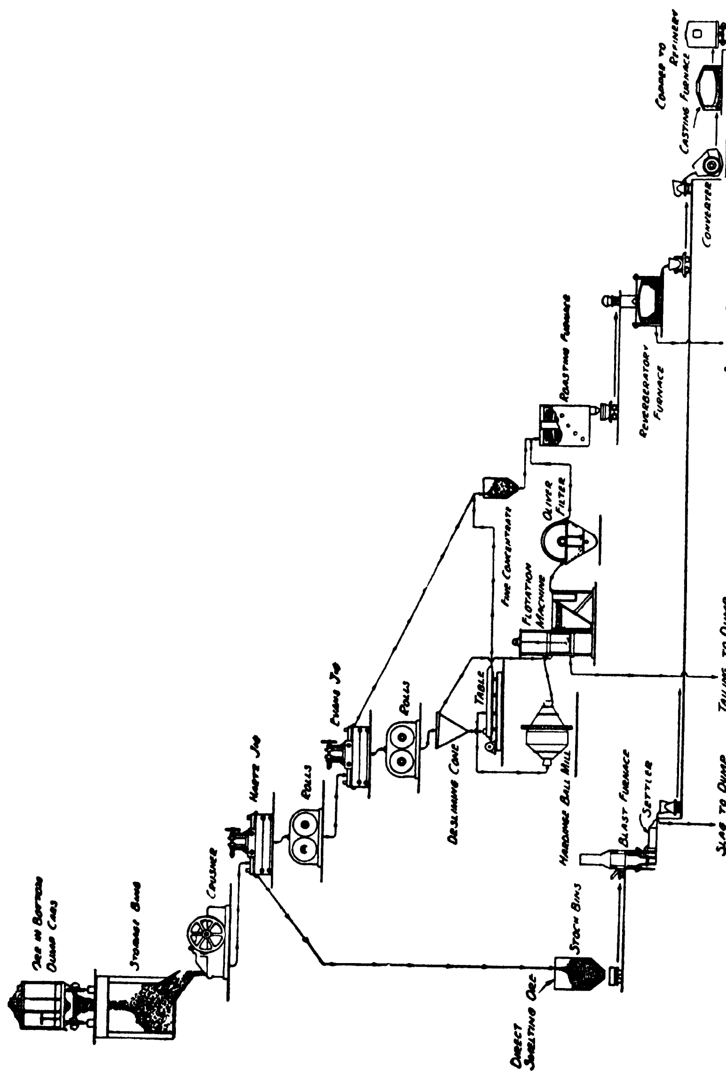


Figure 71. Diagram Showing Steps in Reduction of Copper Ore
(Courtesy of Anaconda Copper Mining Co.)

and greatly simplifies the administration. A minimum amount of labor is required and that chiefly for emergencies, for quality inspection, and to maintain the equipment. Figure 71 shows the sequence of processes, characteristic of this kind of production, in an ore reduction works where gravity plays a large part in material handling.

The manufacture of starch and allied products from corn provides an example of analytical manufacture. Shelled corn is received in cars and is carried by mechanical equipment into the elevators for storage. As needed it is conveyed into hoppers which feed the production processes. Once started into the machinery it passes automatically through successive processes or treatments. The corn kernel is separated and divided, and each part proceeds on a predetermined route until finally at the various ends of the system there emerge finished products in the form of feed, oil, glucose, syrup, and various kinds of starch.

The selection of the equipment for such an industry is not subject to much variation, yet similar plants do utilize in part different processes and consequently different equipment. This is due to improvements effected from time to time, and to discovery by chemists of more simple and effective processses. Buildings simply envelop the processes and provide structural support for equipment. Multi-story structures are invariably utilized in order to facilitate gravity handling of material in process.

The manufacture of flour is typical of continuous process production by mechanical methods. Wheat is converted into flour, bran, and feed. The equipment and layout for accomplishing this is well standardized, the output is uniform as to quality, and little managerial supervision is required.

Special Arrangements for Particular Types of Plants.—Individuality in arrangements to fit production requirements is a characteristic of structures in the metal trades industry. In gray iron foundries 100 tons of handling is involved for each ton of product. The building of machinery requires operations on heavy parts, often bulky. These considerations suggest straight-line layouts and the need for built-in operating equipment, such as overhead cranes. Figure 72 illustrates a good layout for a large foundry. Note the straight-line movement of materials: from cars to bins or into storage, thence through melting, pouring, and cleaning operations to the shipping platform. Mechanical handling equipment is a feature of this scheme, and implies a thorough understanding of operation needs as an essential to layout, design, and installation. This type of structure cannot be expanded advantageously by enlarging floor areas, because of the combination of equipment and structural features and the

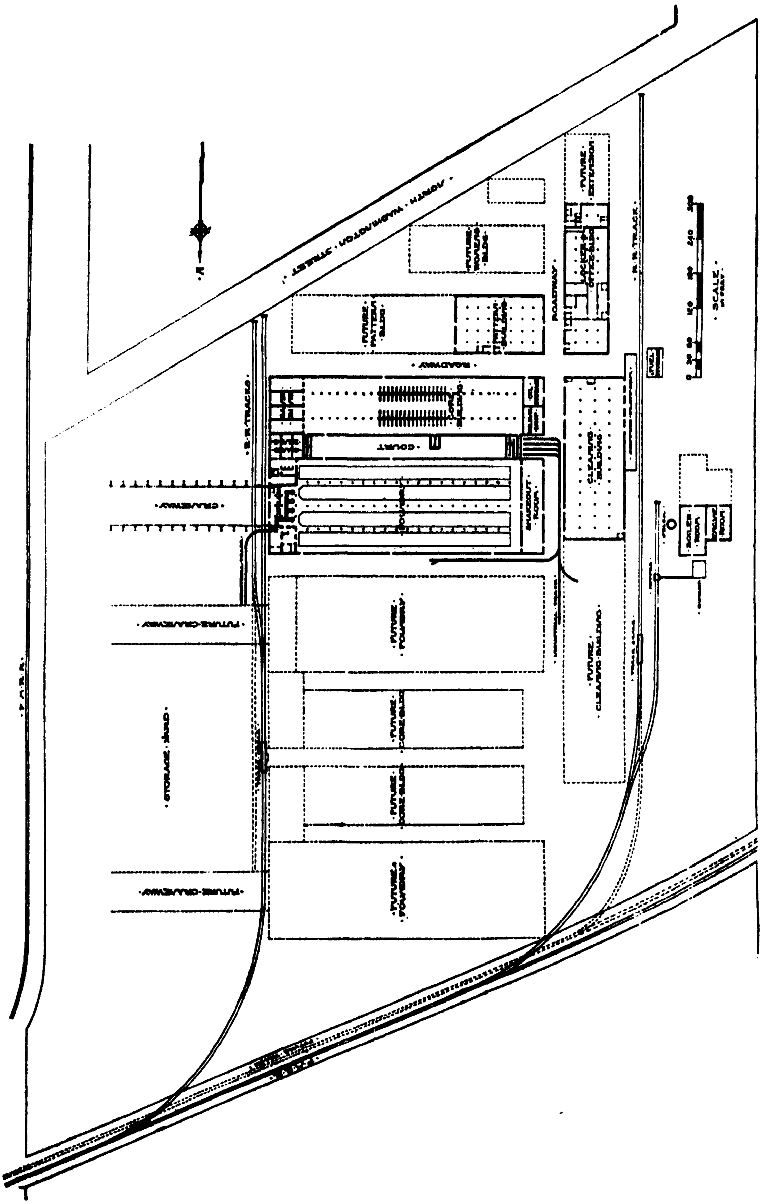


Figure 72. Example of Straight-Line Production Layout in a Foundry

operating problems involved. Additional capacity is secured by the building of new units, the need for which should be anticipated when the plant is first planned. In this case an ultimate capacity of three times the present capacity has been provided for, assuring development along normal lines.

Manufacturers whose lines include several hundred items, involving the completion of as many thousand parts, are combining the departmental plan of machine arrangement with the production line arrangement. When an item is produced in sufficient volume the production line arrangement may be used. Sometimes the equipment can be arranged to turn out several parts with a minimum of idle machine time. Those parts produced in smaller volume are routed to departments as formerly. In furniture manufacturing the sequence of operations is likely to be the same for many styles and sizes of products; for example, the same machine may be used in a sanding or surfacing operation for many different parts. In these cases layout is greatly simplified. The building of freight cars is accomplished by a continuous forward movement of the cars on their own trucks along a track through successive work stations where the separately manufactured parts are assembled. The assembly lines of automobile plants give another illustration of this idea of progressive manufacture.

Where gravity may be used in handling material a vertical plan of layout is suggested, for example, in such establishments as bottling plants, medicine factories, chemical plants, starch factories, breakfast food plants, or flour mills. In these plants the product is stored on the ground floor areas and conveyed to top floors as needed, thus eliminating the need for heavy floor constructions above. Light-weight goods, such as candies and small parts, lend themselves to multi-floor layouts, with manufacture progressing in a downward direction. In the case of heavy materials which are reduced in weight and bulk as succeeding operations are performed, the first operations may be located on the ground floor and the finishing operations above.

The modern newspaper plant presents a layout problem essentially the same as in the mechanical trades, although the product is radically different. The time element here is of supreme importance, accomplishment being gauged in seconds. Reliability and certainty of function must likewise be assured. To this end working arrangements must be simple and direct, so as to eliminate distance, delay, and confusion; there must be perfect coordination of all departments; and machinery, equipment, or materials must never fail. Figure 73 shows the layout of the composing room floor of the *Milwaukee Journal*.

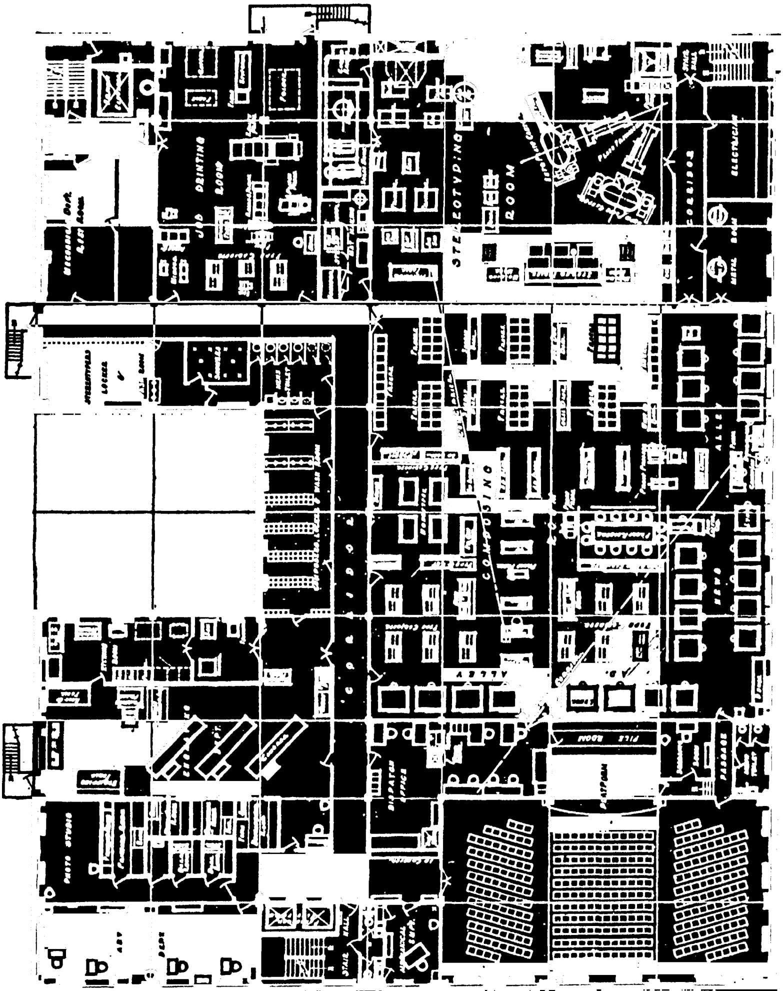


Figure 73. Layout of Composing Room of *Milwaukee Journal*

Current news and editorial material are delivered to the news alley by dumbwaiter from the editorial desk on the floor below. With this exception all material is handled through the planning department, known here as the dispatch office, which issues copy and ads to the respective composing room departments with complete instructions for handling. This separates planning from performance and insures greater speed in doing work. The art, photo, and engraving departments are in the proper relation to each other and subject to the direction of the same production executive. The arrangement of the composing room is such

that work flows smoothly and directly from linotypes to composing tables and directly toward the steam tables where *papier maché* matrices are made; thence by dumbwaiter to the stereotyping machines in the press room several floors below. Supplementary equipment for the various processes is arranged conveniently. All work is made up or handled on wheeled tables or trucks. For perfect freedom of movement and ideal grouping of equipment the entire space is kept free from obstructing columns. (See Figure 74.) In order to stimulate and maintain the highest standard of mental activity the most advanced ideas with regard to all factors affecting physical comfort were incorporated into the arrangements. These include lighting, air conditioning, elimination of noise, easy handling of work, comfortable floors, and general completeness of equipment.

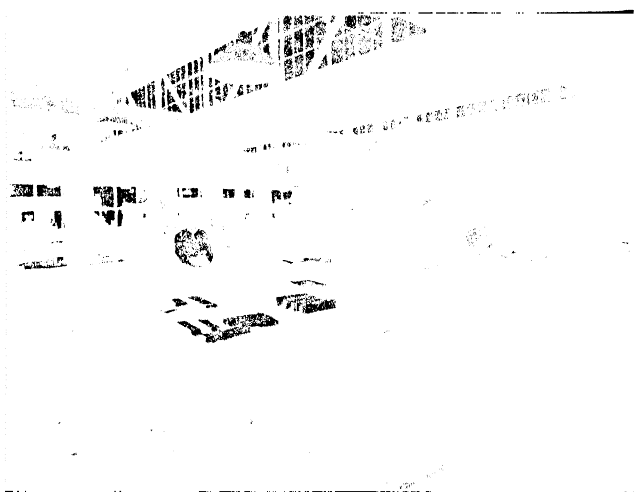


Figure 74. View of the Composing Room, *Milwaukee Journal*

The importance of making layout analyses cannot be overemphasized. Production costs have been reduced as much as 45% by providing proper layouts and equipment, and direct labor costs have been decreased by one-half following a rearrangement of machines and work areas. In a publishing plant the economical arrangement of presses could not be effected with the usual rectangular column spacing, so the columns were "staggered," giving diamond shaped areas. By visualizing the situation beforehand, ideal production layouts may be housed with but few restrictions from structural requirements.

Comfort of the Employees.—The correct technical combination of materials, machinery, and operating areas is important from the point of view of a production analyst, but equally important is the impression made upon the human element which operates it. The location of offices away from noise, vibration, heat, and fumes is appreciated by the clerical force. Conveniently placed, sanitary wash rooms, drinking fountains, and lunch rooms add to the comfort of the employees. Careful study should be given to the proper amount of light, air conditioning, and heating in relation to the kind of work being done. Sufficient work space should be allowed so that a feeling of crowding does not occur. Human beings like to look upon themselves as individuals, and resent being forced into workplaces that make them only part of a group. Attractive surroundings, both in and outside the plant, are appreciated.

All such matters have an effect on the morale and attitude of the working force. Labor difficulties are less bitter and sometimes obviated entirely when employees realize their comfort and convenience is as important to the company as the speed of production. Consideration of the human element should be included in the layout plans, and if necessary modifications made in building designs or equipment arrangements in order to achieve better working conditions.

CHAPTER 15

INDUSTRIAL LIGHTING

Defective Vision.—Seeing is a common place activity; so much so that its importance and effectiveness are neglected. The eyes have evolved under outdoor conditions with natural light. Seeing in the past has been largely a matter of general vision, with close visual work only an occasional need. Today, for many people, there is need to use the eyes for many hours each day at tasks which are unusually exacting, and under conditions which require artificial light. Poor lighting has been the rule in homes, schools, and workplaces and partly accounts for the fact that 50% or more of industrial employees have defective vision. Yet it is recognized that the worker learns mostly by seeing, and uses his eyes to direct muscular activity; utilizing a considerable amount of both nervous and physical energy. Furthermore, persons over 35 years of age experience a decreasing ability to focus the eyes readily to view small objects. This causes eye fatigue. Normally, persons need glasses for close work by the time they reach the age of forty. For these reasons many manufacturers have their workers' eyes examined as a necessary prerequisite to effective and safe production.

A survey made in the plant of a company in the metal trades industry showed that 38% of their employees were suffering from defective vision of some kind which impaired their efficiency. The employees of this company had not been given an eye examination when hired. The importance of such examinations and of re-examinations at intervals is apparent.

The Benefits of Good Lighting.—While the necessity of good lighting is so evident that a list of its benefits may seem commonplace, these same benefits are of the greatest importance in their contribution to effective, low-cost production and industrial relations management. The advantages resulting from improved lighting are as follows: [1]

Advantages to eyes—
- Reduces fatigue.
- Vision more acute.
- Greater seeing-power.

[1] "Mercury Lighting Is Modern Lighting," a booklet issued by the General Electric Vapor Lamp Company.

- Advantages to production—
  - Reduces spoilage.
  - Improves quality.
  - Increases production.
- Advantages to worker—
  - Reduces accidents.
  - Improves general comfort.
  - Decreases nervous strain.
  - Healthier working conditions.
- Advantages to management—
  - Increases profit.
  - Protects equipment.
  - Improves shop appearance.
  - Assures more uniform product.
  - Keeps workers active and alert.

Good lighting may be considered as a production tool which increases the speed and ease of vision, and thus facilitates the use of machines and equipment. With adequate and proper illumination perception is quicker, and there is less uncertainty, hesitation, and needless motion. Workmen have a sureness and certainty of action that enables them to accomplish more and better work and reduce spoilage. Perhaps 25% of spoilage would be eliminated by better lighting.

Eyestrain with good lighting is definitely reduced, and this is important, for it is estimated that of the total nervous energy expended by the worker at his task, the eyes utilize 10% to 15% or more. Uncertainty in seeing contributes to accidents, and mental sluggishness incident to fatigue may be another contributing cause. Accident statistics indicate that many more accidents occur during seasons of the year when there is less daylight, and during hours of the day when daylight is deficient or lacking. Industrial accident records show more accidents per worker for night shifts than day shifts. A worker's ability to see clearly reduces accidents incurred in handling tools and materials, and in falls, causes of most accidents.

A dark workplace is depressing and quantity plus quality production is not associated with a gloomy environment. It usually means a dirty place, for wherever there is an absence of light, dirt tends to accumulate. Neatness is absent and the inevitable accumulation of tools, materials, and spoiled parts leads to insanitary and unsafe conditions. Such conditions affect employment, for workers prefer the cheerful, well-kept plant. The psychological effect of a cheerful, uniformly lighted plant induces employees to work with enthusiasm in a happy frame of mind.

Good lighting eliminates unproductive floor areas and thus contributes to more effective use of factory space. Supervision is less a problem when there are no dark corners where restless or indolent workers may loiter unobserved.

At least eight states have adopted industrial lighting codes establishing safety standards for industry, but the requirements are not sufficient to assure economical production. The American Standard code of lighting prepared by the Illuminating Engineering Society, New York City, prescribes the best current practice. Lighting equipment companies also provide tables of recommended lighting intensities for industrial interiors and operations.

Health and Accidents.—There are definite eye diseases resulting from extremely poor illumination, intense heat with light, and from exposure to energy rays outside the range of vision. These are peculiar to particular industries, as mining, the steel and glass industries, and the motion picture industry. While serious, these diseases are confined within comparatively narrow limits, are recognized, and safety precautions are usually taken to guard against them. Gases given off by processes may prove detrimental, yet difficult to identify as a cause of inflammatory eye conditions. For several years silk manufacturers were puzzled by a problem of this kind. However, it is the generally unrecognized inadequate and improper illumination throughout industry which has taken the greatest toll in impairment of vision and health of industrial workers.

Safety glasses or goggles should be provided for all workers performing tasks where eye accidents are a hazard. These include many metal cutting operations, chipping, buffing, and cleaning operations, handling of wire, pouring of metal in foundries, and tasks involving heat and explosion hazards. If the worker ordinarily wears glasses it may be necessary to provide safety glasses with specially ground lenses to insure good vision. With women workers the comfort and appearance of this safety equipment needs to be considered, as these factors influence its use.

Definitions.—The definitions of some common lighting terms are as follows:

Candle power—The average horizontal intensity of the light from a standard candle is taken as the unit of luminous intensity, and is called a "candlepower." A standard candle is one made in a specified manner and burned under prescribed conditions.[2]

[2] "Artificial Light and Its Application," p. 40, Westinghouse Lamp Company.

Foot-candle—A foot-candle represents the intensity of illumination at a point on a surface which is one foot distant from and perpendicular to the rays of a one candlepower light source.

Lumen—The lumen is the unit of light quantity. It is the quantity of light spread over one square foot of area which will illuminate that area to an intensity of one foot-candle.

Good Lighting.—Good lighting requires three things:[3]

1. Light of suitable quality—
   (a) Absence of glare.
   (b) Absence of reflected glare.
   (c) Proper color.
2. Light of the proper direction—
   (a) Shadows soft and luminous.
   (b) Uniform distribution.
3. Light of the correct intensity—
   (a) Lighting for safety.
   (b) Lighting for production.
   (c) Proper maintenance.

Light of Suitable Quality.—The rapid progress made in scientific illumination has been so unusual that the inexpert are likely to use both equipment and illuminant wrongly and produce bad results. Glare represents one of the most common and serious faults in a lighting installation. It may be defined as any excessive brightness within the field of vision. It (1) causes discomfort and fatigue; (2) interferes with closer vision, reducing efficiency and increasing the risk of accident; and (3) tends to injure the eye and cause a disturbance of the nervous system. The principal causes of glare are: (1) excessive brightness of the light source; (2) too great a volume of light; (3) excessive contrast with background; (4) specular reflection from the object on which the eye is focused; and (5) time of exposure. The eye contracts in about one second to protect itself from glare, but almost a full minute is needed for readjustment to normal seeing.

The human eye is capable of adapting itself to illumination intensities varying from less than a foot-candle (few hundredths) to a maximum outdoor daylight of 10,000 foot-candles; but as we approach the lower end of this range poor vision results from lack of sufficient light to dis-

[3] From a pamphlet entitled, "What an Industrial Lighting Salesman Should Know," National Lamp Works of the General Electric Company.

tinguish details, and in the other case because of the blinding effect of high intensities which obliterates details. With the entire field of view of the same brightness the eye will function without strain for general seeing over a range of 4 to 4,000 foot-candles. Contrast values for full vision should not exceed 1 to 10, and preferably 1 to 5, foot-candles. Outdoor ratios are commonly not over 1 to 25. The most common and troublesome cases of glare are those which are due to unshaded or inadequately shaded lamps or improperly placed lighting units within the field of view. Sky brightness rarely exceeds 3 candles per square inch and ordinarily the brightness of a lighting unit in the field of vision should not be greater than 2 to 5 candles per square inch of apparent area, and the brightness should be reduced to one-half candle per square inch of apparent area when the unit is constantly in view.

The American Standard code says:

Too frequently glare is assumed to be entirely a question of the brightness of the light source; of equal importance is the question of its total candle power. Experience has shown that a 500-watt lamp in a 10-inch opal globe, or a mercury-vapor lamp of an equivalent light output, hung 7 to 8 feet above the floor and a similar distance ahead of the observer will prove quite as glaring as the exposed filament of a 50-watt incandescent lamp in the same location. The brightness of the opal globe unit is only a few times that of a candle flame, but its total candle power and consequently the quantity of light which reaches the eye is altogether too great, so that its effect is worse than that of the bare filament of lower candle power, although the latter may have a brightness as high as 3,000 candle power per square inch. An unshaded window often causes glare, due of course to the large volume of light rather than to the high brightness of the sky.

The 500-watt opal globe would seldom cause discomfort if placed, say, 80 feet away from the observer, for at this distance the total quantity of light entering the eye would be only one one-hundredth of that received at 8 feet. Again, the same light source would probably be found quite unobjectionable at a distance of 8 feet from the eye provided this distance was obtained by locating the lamp 4 feet ahead of the observer and 7 feet above the eye level; in this case the lamp would scarcely be within the ordinary field of view.[4]

. . . Glare is the more objectionable the more nearly the light source approaches the direct line of sight. While at work the eye is usually directed either horizontally or at an angle below the horizontal. Glaring objects at or below the horizontal should especially be prohibited. The best way to remove light sources out of the direct line of vision is to locate them well up toward

[4] Little interference with vision is experienced when the light source is 20 to 30 degrees away from the normal line of sight. "Lighting Comment," Bulletin 36, p. 9, National Lamp Works of the General Electric Company.

the ceiling. Local lamps, that is, lamps placed close to the work, if used at all, must be particularly well screened.[5]

Wall and Ceiling Finishes.—In order to avoid too great contrasts, the background should be well illuminated. Stippled or mat finishes on walls and ceilings eliminate the glare attending smooth finishes. The ceiling and upper wall surfaces may be finished in light colors in order to reflect most of the light which strikes them, but the lower portions coming within the normal range of vision should reflect less than 50%, if they are not to produce discomfort. Ceilings of "mill-white" or cream color, and upper walls of buff, light green, or gray, reflect about the proper proportions, while the lower parts may be of darker colors. (See Table 5.)

Color Correction of Artificial Light.—Standard Mazda lamps provide a light which serves ordinary requirements of vision satisfactorily.

Table 5. Reflecting Values of Different Colored Surfaces

White—new	82 to 89%	Aluminum	65%
White—old	75 to 85%	Buff	50 to 65%
Cream	62 to 80%	Gray	17 to 63%
Ivory	73 to 78%	Light blue	34 to 61%
Yellow	69 to 75%	Dark tan	30 to 46%
Light green	48 to 75%	Dark red	13 to 30%
		Dark green	11 to 25%

All the colors of daylight are present, but not in the same proportion. "For some operations work can be done more quickly or materials and products identified more accurately if the artificial light supplied is made more closely to approach pure white light." [6] In the incandescent lamp, while light is given off at all wave lengths more light is radiated at the red wave lengths than the blue. By equalizing the light output of the different wave lengths, a pure white light is obtained. The degree of color correction achieved depends upon the degree to which the red waves are absorbed and equalized with the blue waves. Daylight Mazda lamps provide a partial color correction and give a light which approximates in quality that of afternoon sunlight. "In all color work high intensity illumination is of particular importance. In fact it has been found that even uncorrected light of high intensity, 100 to 200 foot candles, from Mazda lamps will give satisfactory color identification." [7] Colored light

[5] Code of Lighting, Illuminating Engineering Society, New York City.
[6] Catalog 26, p. 26, Benjamin Electric Manufacturing Company, Des Plaines, Illinois.
[7] *Ibid.*

is obtainable by the use of gas filled tubes, or by filtering light through various substances as glass, gelatin, and pigments.

Mercury Vapor Lighting.—Mercury vapor light is composed of but four colors; yellow, green, blue, and violet, of which the yellow and green constitute 90% of the effective light, and the blue and violet but 10%. Red light waves, which add little to visual value, cause glare and prove irritating to the eye, are not present. An unnatural bluish cast is given to objects, and most colors appear distorted. The preponderance of yellow-green rays enables the eyes to focus quickly and secure a sharp image which is not blurred by the presence of light rays of other colors. Its particular advantages are the greater clearness of vision which it gives in the discernment of fine detail, the lessened fatigue and eyestrain, freedom from glare, absence of dark shadows, and coolness of the light. Where quick and accurate perception of fine details is necessary, as in the inspection of manufactured products for minute structural or mechanical defects, mercury vapor light has in some instances been found preferable to any other kind of light. The large area of the radiant and corresponding low intensity per square inch eliminates glare, and the length of the light tubes (about 50 inches) enables the light to "flow around obstacles" in a way that does away with dark shadows. It has been used in the Bureau of Engraving at Washington for over 30 years, and quite widely in many industries, as newspaper plants, textile mills, machine shops, foundries, tire and automobile body plants, etc.

The original design consists of a glass tube one inch in diameter and 50 inches long. One end of this tube, enlarged into a bulb for holding metallic mercury, and a small cup at the other end serve as electrodes or carriers for the current, which is supplied to them through lead-in wires sealed in the glass. The tube contains no air or other gas, so that when an electric current is caused to pass from one electrode to the other it vaporizes a small quantity of the mercury which fills the tube. Later 250 and 400-watt lamps with screw bases were developed to be used in the conventional types of industrial lighting fixtures.

The unnatural color appearance which mercury vapor light gives to objects has been an objection to this kind of light, but the introduction of lighting units which combine the blue and green of the mercury vapor with the red and yellow of the incandescent lamp has in part overcome this objection. Color correction is achieved by adding light rather than by subtracting it. A combination, enclosed unit, 5 feet in length, provides a large area light source. (See Figure 77, page 249.) The addition of incandescent light permits recognition of colors, and the combination of light from the two sources contributes to effective vision.

Fluorescent Lighting.—The introduction of fluorescent lamps has opened up new possibilities for effectiveness in connection with color matching, inspection, and other work where intensities of from 25 to 100 foot-candles or more of light are wanted. In fluorescent lamps certain fluorescent materials inside the lamp tube are excited and glow under the ultra-violet energy produced by a discharge through mercury vapor. The efficiency of these lamps is indicated by the following comparisons.

Over-all modern lamp efficiencies:[8]

Incandescent	15 to 20	lumens	per	watt
250-watt, H-2 mercury	25	"	"	"
Daylight fluorescent	29.6	"	"	"
400-watt, H-1 mercury	25	"	"	"
Cooper Hewitt fluorescent	50	"	"	"

Light of various other colors can be produced easily and at efficiencies up to 200 times that of other sources. The low surface brightness of the lamps (about 3 candles per square inch) and the small amount of radiant heat permit location of the lighting units low over the working place and close to workers. They may be connected to ordinary wiring. The lamps are of the tube type, and are obtainable in different sizes and lengths. Fixtures vary in design to fit the need. (See Figure 78, page 250.)

Proper Direction.—Light direction and management of shadows constitute an important phase of industrial lighting. Shadows are as desirable in most cases as the proper degree of light, but they must be of the proper density and rightly placed, i.e., natural. They are an aid to visual perception of objects with three dimensions, except when they become so sharp or so dark as to make it difficult to distinguish between shadows and objects, and to perceive detail. Without them objects would appear flat.

Natural light from windows in industrial workplaces often gives greater light on vertical working planes than horizontal. Artificial illumination, on the other hand, has usually been designed with first thought for horizontal working planes and with the assumption that enough illumination would thereby be provided on oblique and vertical planes. This has been the cause of much deficient illumination. In machine shops, assembly departments, textile mills, and for innumerable other industrial processes, the illumination of other than horizontal planes is most important. Units should be chosen which give relatively good illumination in the 50–70 degree zone as well as more directly downward.

[8] From data supplied by the General Electric Vapor Lamp Company.

The RLM standard dome porcelain-enameled metal reflector provides 50% as much illumination on the vertical plane as on the horizontal; hence, if more is desired the lamp power will need to be increased proportionately.[9]

Another factor in effective lighting is the redirection of the light rays by reflection from ceiling, walls, stored materials, and equipment, and the size and proportion of room areas. Reflected light helps to eliminate dark shadows and produces a more uniform illumination. The practice of painting machinery a standard gray or sand color rather than black, which absorbs almost all the light it receives, aids in this. Shadows are needed, but they must be controlled and made as natural as possible.

Proper Intensity.—In choosing the correct intensity of illumination for a given process, much depends upon the individual conditions prevailing, and hence in tables general figures only can be provided. The character of the task, color of materials, the effect of light on product, the presence of gases, or vapors created, the surroundings, all play a part. Almost always more light can be used economically and profitably than is commonly supplied.

For good lighting the following six general levels of illumination are suggested:

2 to 5 foot-candles—Aisles, stairways, and passageways.

5 foot-candles—Satisfactory for work of a coarse nature, such as coal and ash handling, for warehouses and stockrooms, and where it is not necessary to distinguish details.

10 to 20 foot-candles—Considered good lighting for rough bench and machine work and for medium work on light-colored surfaces.

20 to 50 foot-candles—Good lighting for medium bench and machine work, and for average work on dark-colored surfaces.

50 to 100 foot-candles—Excellent lighting for all work except the most exacting. For fine bench and machine work and most inspection operations.

100 foot-candles and more—For the most exacting tasks such as extra fine assembling, bench and machine work, engraving, testing and inspection. 1,600 foot-candles are used on some inspection operations.

Installations to provide general lighting with intensities of 50 to 80 foot-candles are now in use, examples being provided in printing and publishing plants, automobile factories, and radio assembly work. Where the need for the high intensities is localized, general lighting may be provided of from 20 to 50 foot-candles, supplemented by higher intensities for the work station where it is needed.

It is recognized that a great deal of manufacturing is carried on in areas where the general lighting ranges from 1 to 5 foot-candles, and local lighting at the point of work, when supplied, from 8 to 15 foot-candles. In the light of recent experience this is poor economy.

Figure 75 shows the relationship between intensity of illumination and reaction time as determined by laboratory tests. The effect of good

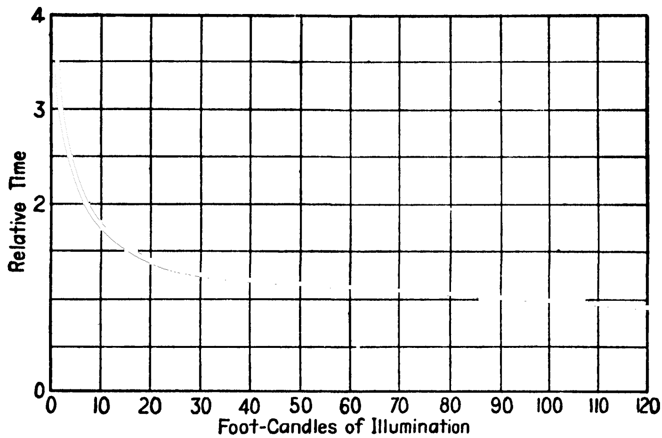


Figure 75. Intensity of Illumination Affects Reaction Time

vision and adequate illumination upon the time for doing work calling for the discernment of detail is apparent.

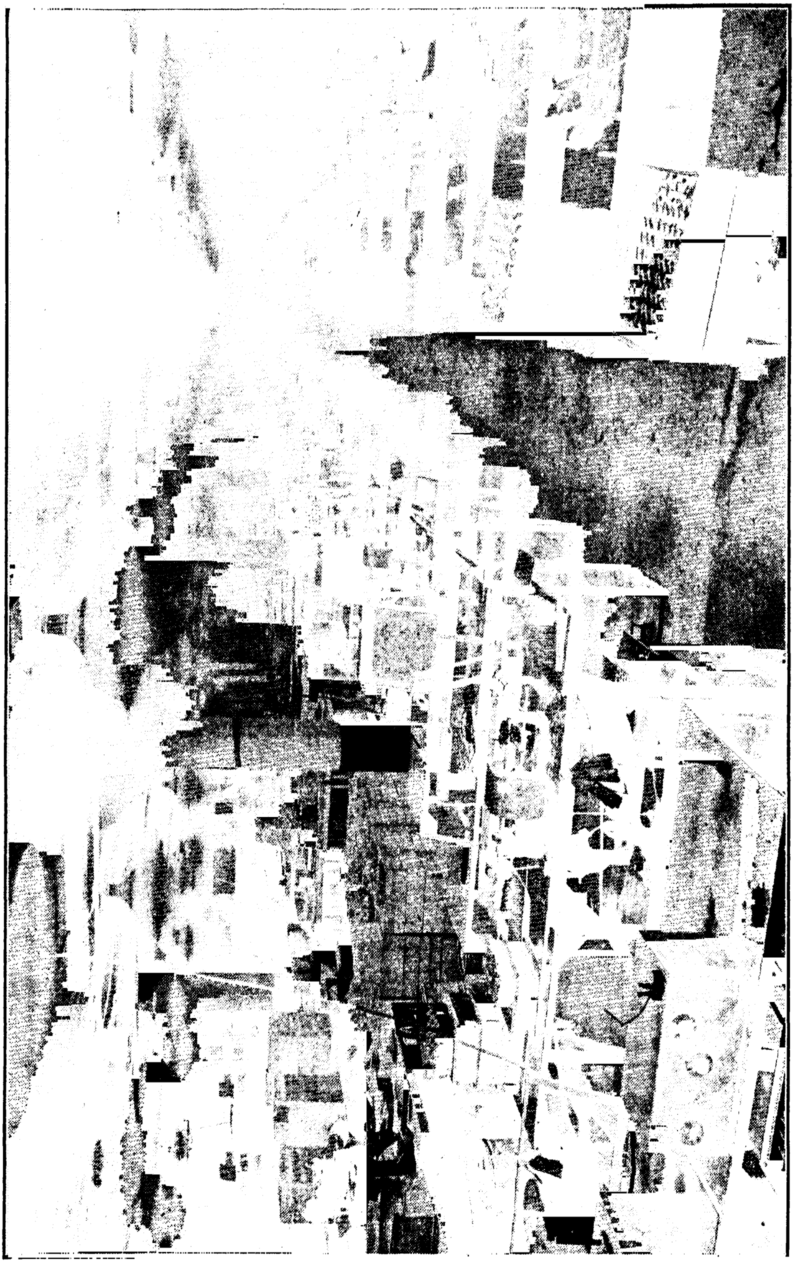
Recommended Intensities of Illumination.—Recommended intensities of illumination for some particular tasks are provided in Table 6.[10]

Examples of Good Lighting.—Figure 76 shows a high intensity combination mercury vapor and incandescent lamp installation in an assembly department of a radio plant. An average of 80 foot-candles of light is supplied at the working level.

[10] For complete table see Catalog No. 50, Series B, Wheeler Reflector Company, Boston, Massachusetts.

TABLE 6. TABLE OF RECOMMENDED FOOT-CANDLE VALUES FOR ILLUMINATION OF INDUSTRIAL INTERIORS

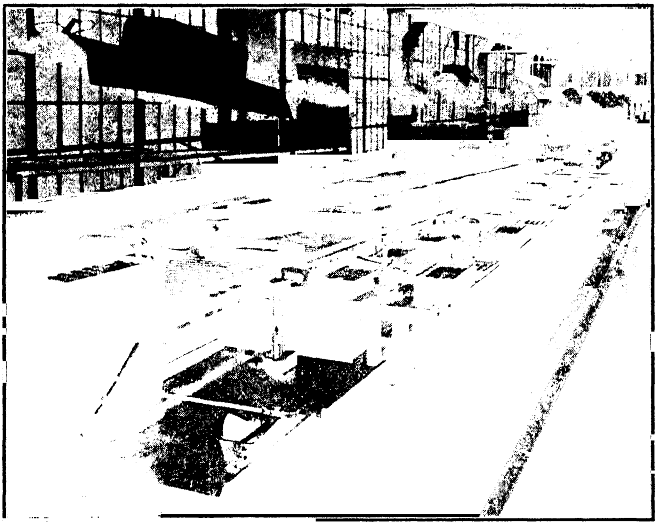
Assembling:	
Rough	10
Medium	20
Fine	50–100
Extra Fine	100 plus
Automobile Manufacturing:	
Automatic screw machines	10– 20
Assembly line	50–100
Frame assembly	20
Tool making	20– 30
Body manufacturing:	
Assembly	20
Finishing and inspect.	100 plus
Bakeries	20
Book Binding:	
Folding, assembling, pasting, etc.	10
Cutting, Punching, and stitching	20
Embossing	20
Candy making	20
Cloth Products:	
Cutting, inspecting, sewing	
Light goods	20
Dark goods	50–100
Engraving	100 plus
Foundries:	
General	5–10
Fine	
Molding and core making	20
Machine Shops:	
Rough bench and machine work	10
Medium bench and machine work	20
Fine bench and machine work	50–100
Extra fine bench and machine work	100 plus
Offices:	
Close work	20–30
No close work	10–20
Drafting room	30–50
Packing:	
Crating and boxing	10
Paper Box Manufacturing:	
Light	10
Dark	20
Storage of stock	5
Soap Manufacturing	10
Woodworking:	
Rough sawing and bench work	10
Medium machine and bench work, etc.	20
Fine bench and machine work, finishing, etc.	30



(Courtesy of Benjamin Electric Mfg. Co.)

Figure 76. High Intensity Lighting in Factory of Philco Radio & Television Corporation

Figure 77 shows the use of mercury vapor lights in combination with daylight in assembling the jewels and speed cups for speedometers in the plant of the A. C. Spark Plug Company, Flint, Michigan. The engineer in charge said: "We find that the mercury-vapor light gives us the best satisfaction on fine or highly polished materials, as it has a tendency to bring out the defects with less eyestrain to the operator, even more so than daylight. It is a practice on some of the operations that are very particular, to use the mercury vapor lamp at all times, as we find that

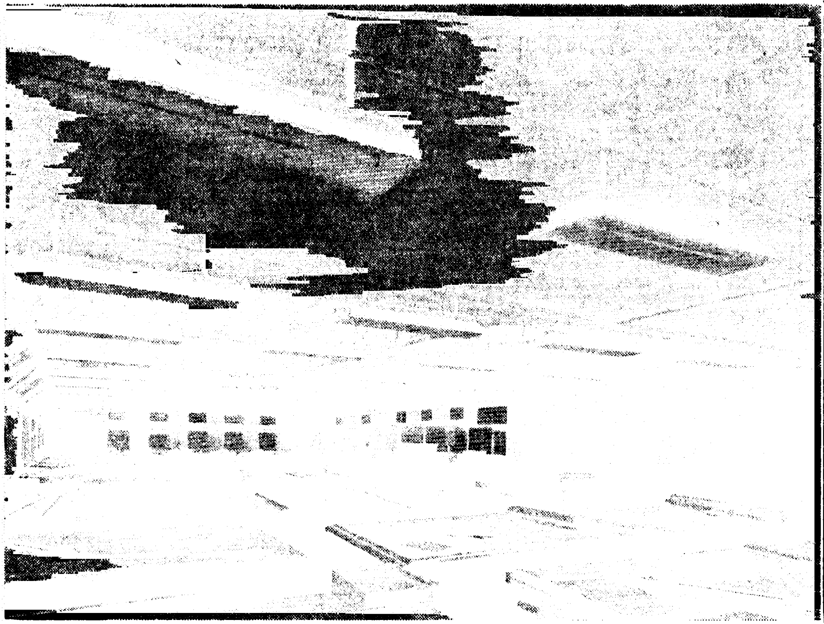


(Courtesy of General Electric Vapor Lamp Co.)

Figure 77. Mercury Vapor Lighting in A. C. Spark Plug Plant

the light from the windows, even on a clear day, changes in intensity, and coming from only one side casts shadows on the work and gives a little poorer inspection than we get with the artificial light. We are using light at about 30 foot-candles." In some inspection departments daylight is entirely excluded in order to avoid the variation which results between bright days and dark, gloomy ones. Workers in some textile weaving departments show a preference for artificial illumination to natural light.

Improved Lighting Increases Production.—In the plant of the Timken Roller Bearing Company careful tests showed that production varied with the intensity and quality of illumination. The raising of the illumination from 5 to 20 foot-candles brought about an increase of



(Courtesy of Wheeler Reflector Co.)

Figure 78. Fluorescent Daylight Lamps in the Drafting Room at the Vega Airplane Factory, Burbank, California

12.5% in production. An initial gain in production of 4% was achieved mainly by eliminating glare and troublesome shadows.

Gains in production from improved lighting are a result not only of increasing the intensities of illumination, but of correcting other lighting deficiencies. Production gains of from 5% to 25% frequently accrue from lighting improvements. An investigation by The Austin Company, Engineers and Builders, Cleveland, Ohio, disclosed the following:

Class of Work	Foot Candles Old	Foot Candles New	Production Increase Per Cent
Stamping and pressing	0.7	13.0	12.2
Semi-automatic buffing	3.8	11.0	8.5
Soft metal bearings	4.6	12.7	15.0
Heavy steel machining	3.8	11.0	10.0
Carburetor assembling	2.1	12.5	12.0
Spinning (textile)	1.5	9.0	17.0

Cleaning and Maintenance.—The service rendered by both natural and artificial lighting equipment deteriorates very rapidly unless properly maintained. In every factory there should be a regular and definite system of maintenance providing for the cleaning and repair of glass

areas, lamps, and reflectors, and replacement of burned-out lamps. Walls, ceilings, and other reflecting surfaces, including equipment, should be repainted regularly. Properly painted ceilings will increase the illumination when indirect or semi-indirect systems of lighting are used.

It is well to know that from 40% to 60% of the money paid for light may be wasted through lack of cleaning and upkeep; while all the benefits of good lighting are lost. The cost of cleaning lamps is about 5% of the total operating cost of a lighting system, and the increase in illumination is 25% to 50% more.[11]

UNDESIRABLE NATURAL AND ARTIFICIAL LIGHTING CONDITIONS

DEFECTS OF FACTORY LIGHTING	IMPROPER DAYLIGHT	POOR LIGHTING	MISUSED EQUIPMENT
DIRECT GLARE	Great volume of light too bright for comfort MODIFY BY CURTAINS OR BLINDS OVER LOWER PORTION OF WINDOW	Lamp filament or bright unit in field of vision CORRECT BY MOUNTING UNITS PROPERLY	Lamp size not suited to equipment CORRECT BY USING LARGER REFLECTORS OR GLOBES
REFLECTED GLARE	Sunlight is very directional, thus readily reflected SHADE WINDOWS OR FACE AWAY FROM THEM	Very apt to occur where there are polished surfaces CORRECT BY THE USE OF DIFFUSING GLASSWARE	Incorrect type of unit USE EQUIPMENT WITH AS MUCH DIFFUSION AS POSSIBLE
LOW INTENSITY	Great variation depending on weather conditions and distance from windows SUPPLEMENT WITH BLENDING ARTIFICIAL LIGHT	Inefficient methods and insufficient wattage IMPROVE BY USING EFFECTIVE EQUIPMENT OF THE PROPER SIZE	Lamp size inadequate for area lighted IMPROVE THROUGH THE USE OF MORE WATTAGE
NON-UNIFORMITY	High intensity near windows, fading rapidly toward interior of room IMPROVE BY USING SKY-LIGHTS OR SUPPLEMENTAL ARTIFICIAL LIGHT	Poor characteristics of units (usually too concentrating) IMPROVE BY GOOD EQUIPMENT, PROPERLY SPACED	Units placed too far apart for their mounting height RELOCATE IN ACCORDANCE WITH THEIR DISTRIBUTION DESIGN
SHADOWS	Light comes predominantly from one direction MODIFY BY USING DIFFUSING WINDOW GLASS OR CURTAINS	Equipment not sufficiently diffusing for mounting height MODIFY THROUGH THE USE OF DIFFUSING LAMPS OR ACCESSORIES	Equipment incorrectly chosen or installed ELIMINATE BY PROPERLY DESIGNED LAYOUT
APPEARANCE	Windows dirty, walls and ceilings badly painted CLEAN REGULARLY-PAINT WITH LIGHT COLORS PERIODICALLY	Units poorly designed ("dirt catchers") and poorly maintained USE AND MAINTAIN EQUIPMENT IN KEEPING WITH WORKING CONDITIONS	Units dirty and surroundings badly painted CLEAN REGULARLY-PAINT WITH LIGHT COLORS PERIODICALLY

Figure 79. Undesirable Natural and Artificial Lighting Conditions and Their Correction

[11] Instruction Booklet No. 30344, General Electric Vapor Lamp Company, Hoboken, New Jersey.

Ways of remedying some common lighting defects are suggested in Figure 79.[12]

In designing lighting systems, full allowance must be made for depreciation of lamps, unavoidable dust and dirt on reflectors, walls, ceilings, and other reflecting surfaces, and care taken that current of the proper voltage for the lamps is supplied. At the Ferro Machine and Foundry Company, where but little attempt had ever been made to keep the windows clean, a thorough scrubbing increased the illumination from 3 foot-candles to 11 foot-candles, a gain of 266%. Another workshop with a large glass area showed a gain in light intensity from 7 to 15 foot-candles by cleaning the windows inside and out.[13] These examples are typical of conditions permitted to prevail through lack of appreciation and attention.

Utilizing Natural Light.—Figure 80 indicates clearly the present appreciation of the value of good, natural lighting as contrasted with the past. With 80% to 90% of wall areas in glass, buildings 60 feet in width may be readily daylighted.[14] With continuous windows in side-walls, possible with special reinforced concrete and steel construction, or by using prism glass, this width may be much increased. Clear glass areas which permit the worker to relax and rest the eyes occasionally by gazing outside are sometimes considered desirable.

Ceiling designs are also a factor. Flat slab concrete construction provides a flat ceiling which is ideal for light reflection. When beams and girders are used they should be placed, if practicable, at right angles to the windows so as not to obstruct the light. The elimination of overhead shafting and belt drives, forethought in the placing of machinery, care in the storage of materials, the use of wire partitions and proper painting of surfaces contribute to the best utilization of the available light. In aircraft plants a recent practice is to paint the floors white so as to reflect light to the underside of wing surfaces.

Foundries, forge shops, and other branches of the metal trades industry find it necessary to utilize special roof construction as discussed in the chapter on building construction. These comprise M-shaped roof trusses, A-frames, skylights, sawtooths, and monitors. They are a big factor in obtaining light, such glass areas frequently being measured in thousands

[12] "How to Get Better Seeing," by Samuel G. Hibben, *Factory Management and Maintenance*, Vol. 92, No. 3, p. 99.

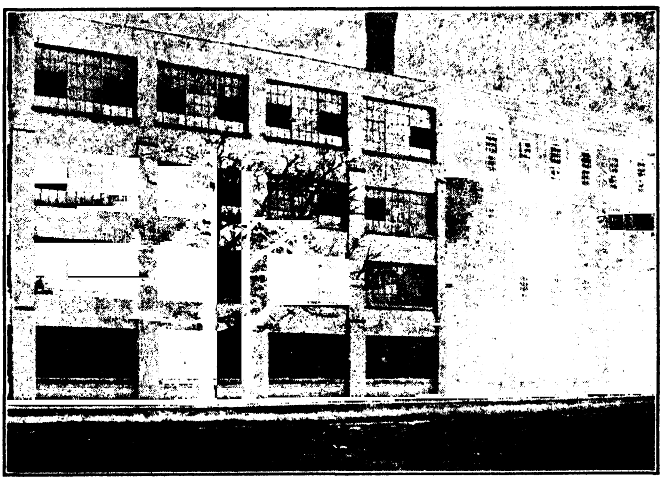
[13] "Bringing Daylight into Your Present Building," by W. T. Spivey, *Factory*, Vol. 31, No. 3, pp. 312–315.

[14] For the best lighting the height to top of glass in windows should not be less than one-half the depth of the room (windows on one side) and the glass area should be at least 30% and preferably more nearly 40% of the floor area. Pilasters or mullions should be limited to one-quarter the width of the glass area between them.

of square feet. Likewise, the side walls are often almost entirely of glass consisting of long runs of motor-controlled sash which can be opened for ventilation, as in Figure 91, page 279. The top floors of multi-story buildings may be better lighted by adopting some form of roof lighting to supplement side wall sash.

Manufacturing buildings with glass block walls provide unusual daylighting. As described in the chapter dealing with buildings, glass blocks are translucent, but not transparent, admitting up to about 85% of the light, depending upon the prism design. For hours when sufficient daylight is lacking, dependence must be placed on artificial lighting systems.

Unsatisfactory natural lighting may be due to one or more of the following causes: (1) old and unsuitable buildings, (2) obstruction of light by exterior surroundings, (3) dirty glass areas, (4) failure to clean or paint walls and ceilings, (5) obstructions of light by equipment, materials, or solid partitions, (6) failure to utilize roof areas to advantage, (7) obsolete ideas and design, etc. The substitution of individual motor drive for machines and the elimination of overhead shafts and belting has been a big factor for better daylight illumination.



(Courtesy of Detroit Steel Products Co.)

Figure 80. The New and the Old in Factory Windows

Cost of Lighting.—The money cost of supplying light per individual workman is likely to be overestimated. The difference in relative cost of labor and light in the factory is very great. Assuming that each workman utilizes the light from one 300-watt unit for 1,000 hours each year, the following figures are approximately correct:

Investment:

Cost of 300-watt mogul base lamp and 300-watt Turnlox type RLM Dome Reflector and wiring per outlet	$12.50

Operating Expenses:

Fixed interest, taxes, and insurance at 10%	$ 1.25
Depreciation on reflector and wiring at 12½%	1.56
Renewal of lamp, rated life 1,000 hours	.58
Cleaning 12 times a year at $0.03 per cleaning	.36
Energy at $0.15 per kw-hr., or 1,000 hours	4.50
Total annual operating cost	$ 8.25

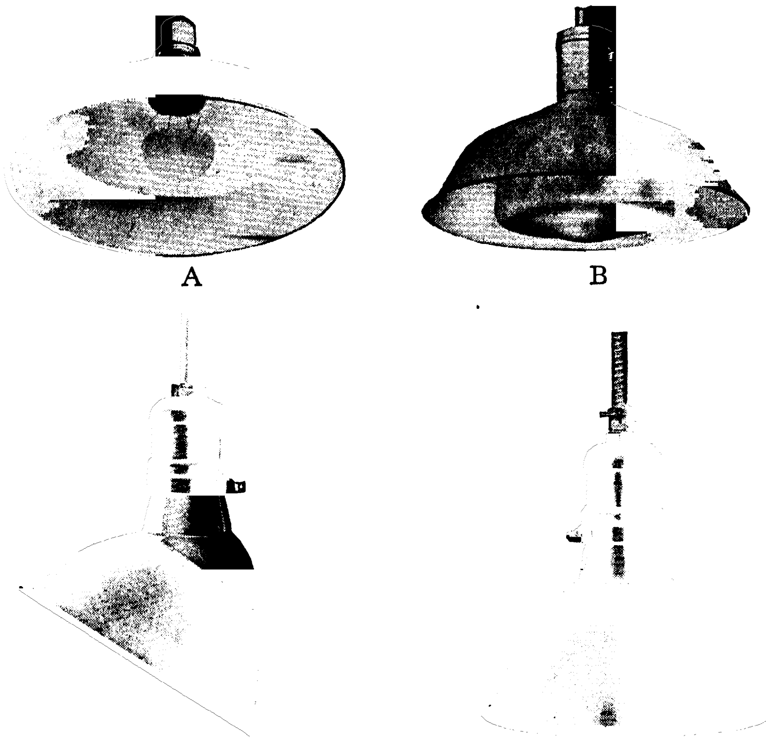
The operating cost per hour would be less than 1¢. Where large overhead units provide illumination for, say, four men, adequate light may cost only ½¢ per hour. An automobile industry estimate indicates that by saving 10% on lighting costs they might save 1¢ per car, but if they apply 10% more toward good lighting, production would be increased—resulting in a saving of 25¢ per car.

Daylight may cost as much or more than electric light. Account must be taken of heat losses through glass areas, increased cost of windows and roof constructions, upkeep, interest and depreciation, and of the space occupied by light courts.

Buildings Without Windows.—In recent years many buildings for manufacturing and office use have been built without windows. Such buildings depend entirely upon artificial light, which is supplied with modern fixtures and at high intensities. All areas of floor space including basements and inside rooms are equally advantageous, which adds to use value and permits greater flexibility in arranging workplaces. Employee attitudes toward such arrangements seem to be favorable, possibly because of the unusually effective and cheerful lighting arrangements provided, the circulation of conditioned air, fewer hours of work per day and week than formerly, and a generally favorable attitude toward modern innovations.

Systems of Lighting.—Good lighting calls for illumination of the entire interior and avoidance of excessive contrasts in the field of view or with respect to work requirements, as previously suggested. With this idea in mind many fixtures are designed to transmit most of the light downward to the job, but direct some of the rays horizontally and upward, supplying light to walls and ceilings. See Figure 81B. Others, as Figure 81A, C, and D, direct all the light toward the working areas. Fixtures are also designed to direct all the light upward, where it is reflected from ceilings and wall surfaces to the work areas and supply a totally indirect illumination. General or overhead lighting is accom-

plished with a choice of one of these types of fixtures. If properly designed good vision is possible throughout the work area. Supplementary or "plus" lighting for jobs requiring more light than it is desired to supply generally may be provided by direct lighting units at the point of work.



A—RLM standard dome reflector with bowl-enameled lamp (Courtesy of Edison Lamp Works)
B—Glassteel diffuser with enclosed lamp (Courtesy of Edison Lamp Works)
C—Angle reflector unit
D—Bowl reflector unit

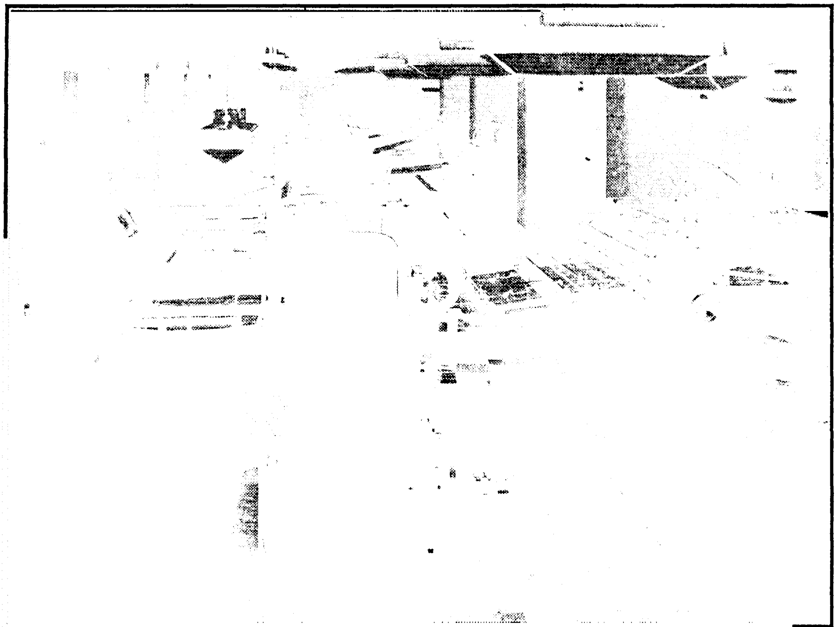
Figure 81. Standard Types of Factory Lighting Units

Direct lighting systems employ reflectors to improve the distribution of the light, diffuse the direct rays from the lamp, and increase the apparent size of the source. They are least affected by dust and dirt, are not dependent upon wall and ceiling reflecting surfaces, and are the most economical to install and operate, as little light is wasted, or lost by absorption.

With direct lighting care must be taken to avoid glare, objectionable

shadows, and too great light contrasts. The RLM standard dome reflectors [15] are used widely for direct lighting in factories, either with a bowl-enameled lamp or with an opal-glass diffusing globe enclosing the lamp to decrease the brightness and minimize glare, and a "glassteel" diffuser to distribute some light to the walls and ceiling. (See Figure 81.)

In indirect lighting the ceilings and walls are utilized for the redirection and diffusion of all the light emitted by the units. With entire ceiling



(Courtesy General Electric Vapor Lamp Co.)

Figure 82. Use of Combination Units with Mercury Vapor and Incandescent Lamps in the Plant of the Hershey Chocolate Company (A windowless plant)

acting as a light source glare is reduced to a minimum and shadows are eliminated. As the reflection from the ceiling is mostly downward, illumination on other than horizontal surfaces is dependent upon reflection from wall and other vertical surfaces, and may be difficult in large areas. Naturally the cost of operation is greater because of the light lost by absorption and the greater effect of dust accumulations on this type of fixture. Where vapors or fumes are present, or the color of materials worked upon absorbs light readily, or reflecting surfaces are lacking, the

[15] A product manufactured by various reflector and lamp manufacturers according to a standard, rigid specification.

system will not prove practical. For tasks which require the perception of three dimensions shadows are needed, especially when the contrast between the object and its background is slight, as in type-setting. Direct lighting is best for work of this kind. However, for close and exacting work indirect lighting is easier on the eyes than any other form of lighting, and where it can be used its advantages will be appreciated. Perfect illumination is afforded by the indirect rays of the sun filtered through clouds, a natural, indirect light.

Semi-indirect lighting offers a combination of the other systems with modification of their disadvantages. The amount of direct light may be controlled by varying the density of the glass reflectors. Oblique and vertical surfaces are better illuminated and the cost of operation is less than with indirect lighting; while from the glare and shadow standpoints the system is an improvement over direct lighting. A good example of semi-direct lighting is shown in Figure 82.

Local Lighting.—Supplementary or "plus" local lighting is needed where the work to be done (1) requires unusual accuracy; (2) necessitates fine distinctions in color or qualities; (3) handling of minute parts; (4) where insufficient light results at the point of work from a general lighting scheme. Where local lighting units are used to supplement general lighting arrangements for doing fine work, it is particularly important that the general illumination be good. Contrasting or spotted illumination not only causes a loss of time, but also undue fatigue resulting from constant eye adjustments. For intensities from 30 to 50 foot-candles, 1/3 to 1/2 of the illumination should be provided by the general lighting; for 100 or more foot-candles, 20 foot-candles or more of general illumination should be used to eliminate objectionable contrasts in the lighting. Local lighting units must be carefully designed and placed to supply adequate light of the proper quality without causing glare. Reflected glare can usually be eliminated by changing the position of the light source, of the work, or by decreasing the brightness of the light sources. Glare due to "time of exposure" can be corrected by decreasing the brightness of the light sources or shifting the position of the workplace or worker. Reflectors should be so arranged that the light falls upon the work and not in the operator's eyes.

USE OF LIGHT IN PROCESSES, ETC.

Ultra-Violet Radiation.—Ultra-violet light is a form of radiant energy of short wave lengths which is invisible to the eye. Some of these ultra-violet rays produce sunburn and aid in activation of vitamin D.

Others are effective in destroying bacteria, molds, and other micro-organisms. The commercial utilization of these rays is proving practical. Micro-organisms may be killed by exposure to them. Disease germs or air-borne bacteria may be eliminated by circulation of the air through ducts where lamps giving off these ultra-violet rays are used. The lamps are used in hospital operating rooms to reduce the bacteria count and promote quick healing. In the preparation and packing of meat, foods and allied products one finds it important to sterilize the containers or wrappers; the surfaces of materials packed in jars and many items subject to the eventual contamination by fungi or molds. In this classification one of the most interesting is the destruction of mold spores in air in bakeries to reduce the mold growths on the bread and on almost any baked goods. Preventing the contamination by radiation seems much more important and much more practical than eventual destruction of spore or fungus after it becomes rooted and growing. In bakeries one 30-inch tube for each 50 to 100 square feet of floor area seems sufficient.

Light for Drying and Heating Operations.—Lamps used for drying and heating operations produce infra-red radiant energy, which penetrates and is absorbed by the surface or material to be dried, causing rapid evaporation of the moisture or solvent. The operation is clean as no fumes are produced. The radiant energy does the drying directly, not by heating the surrounding air. Lamps may be installed anywhere in the production line and in the numbers required. Reflectors direct the radiant energy upon the work, heat losses are low, and insulation against escaping heat is unnecessary. These lamps are being used for heating and drying in connection with many products, including industrial and automotive finishes, surface moisture on metals, blueprints, tobacco, pottery, motor and transformer windings, and paper finishes.

The Stroboscope.—The ordinary filament bulb used for illumination has a definite period during which the filament is heating when the switch is turned on and a period of cooling after the current is turned off. These periods produce a glow increasing or decreasing in intensity but producing sufficient light for vision nevertheless. The stroboscope is a neon lamp in which these periods of glowing are eliminated. Consequently, when it is turned on and off rapidly a series of distinct pictures is presented without any intermediate vision. The result is the same as that presented by a moving picture projection which interrupts a series of pictures and gives the effect of continuous unbroken motion. With the use of the stroboscope an engine running at a speed of 2,000 revolutions

a minute can be made to appear motionless or turning over very slowly according to the speed with which the stroboscope is turned on and off. The effects of torsion on the behavior of the pistons and valves can be studied while the engine is in actual operation. Timing can be checked or the operation of a machine tool studied. Processes that are too rapid for the human eye to follow under ordinary lighting conditions can be brought into clear relief with this instrument and defects noticed and corrected.

Electric Eyes.—The use of photoelectric control devices for industrial purposes has increased greatly in the past few years. These so-called

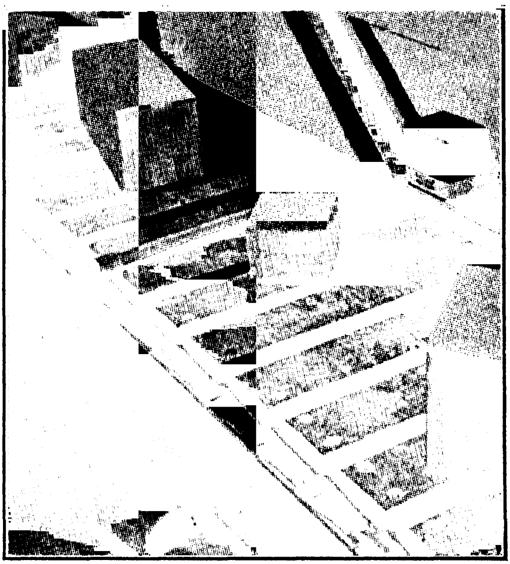


Figure 83. An Electric Eye Counts the Boxes as They Pass on This Conveyor

electric eyes consist of a beam of light falling upon a phototube. The energy so developed can be put to many uses. Placed upon a punch press or other equipment it acts as a safety guard which will not allow the press to operate when any part of the workman's body interrupts the light beam. Figure 83 shows an electric eye counting boxes as they pass along a conveyor. In other applications photoelectric cells have been made to open and shut doors, stop conveyor lines, and act as guardians or watchmen inside and outside a plant. It is possible to obtain equipment which will operate over distances of several thousand feet for this last purpose.

CHAPTER 16

AIR CONDITIONING

Early Development.—Air conditioning consists in controlling the temperature, circulation, humidity, and purity of the air. Air is a mixture of gases: about 99% of nitrogen and oxygen in the ratio of four volumes to one, with small amounts of argon, carbon dioxide, and other gases. Water vapor is normally present in the air in varying amounts, and it may contain impurities like dust, soot, bacteria, and the like. Modern engineering efforts to manufacture weather suitable for various process needs dates from about 1901, and the art of air conditioning was recognized in 1911. In the early years most attention was given to installations designed to reduce the cost and improve the quality of products. Later, the desirability and value of conditioned air for human efficiency, health, and comfort was recognized, leading to added industrial and many commercial and home installations. Year-round air conditioning for reasons of economy and comfort is now generally accepted.

Definitions and Explanations.—The following definitions and explanations of some technical terms necessarily used, will aid the reader in gaining a clear understanding of the subject matter of this chapter.

The Fahrenheit or ordinary dry bulb thermometer registers the degree of heat of the air, but not the quantity of heat. It indicates the ability of the air to transmit heat to objects. As the degree of moistness of the body and the relative humidity of the air also affect the individual's feeling of comfort, the dry bulb does not measure accurately the bodily reaction to atmospheric conditions except at 46 degrees, when a normal amount of clothing is worn.

The wet bulb temperature is the temperature at which the air is saturated with moisture. Under normal conditions it will be less than the dry bulb temperature. The wet bulb thermometer may be made from an ordinary Fahrenheit thermometer by covering the bulb with a moistened wick. The wet bulb temperature may then be secured by whirling it or blowing the air against the bulb with a fan. Such a thermometer is affected by the temperature, and also by the moisture in the air which affects the evaporation, and hence cooling of the bulb. It takes into effect the cooling evaporative effect of air on the body, the latter more or less moist from perspiration. If the body were entirely wet the wet bulb thermometer would register bodily reaction accurately. It measures the bodily reaction more accurately

as the Fahrenheit temperature increases above 46 degrees, and accurately at some point a little below 132 degrees.

The dry bulb temperature with the wet bulb temperature measures the relative humidity of the air and its heat content. The difference between the dry bulb temperature and the wet bulb temperature provides a measure of the cooling effect obtainable by saturating the air.

Effective temperatures register the combined effect of (1) temperature, (2) humidity, and (3) air motion upon the human body. There are innumerable combinations possible of these factors, and different combinations may give equal sensations of warmth or cold. The effective temperature scale provides a single scale to which all combinations of temperature, humidity, and air motion may be referred. Its numerical values are fixed by the temperature of still air,[1] saturated. Thus any combination of air conditions, as above, which gives the same bodily effect as still, saturated air at a given temperature, has the same "effective temperature." For example, an air supply which produces a bodily reaction of warmth equal to that of still, saturated air at 70 degrees, has an effective temperature of 70 degrees. With a given effective temperature a person will always feel the same degree of warmth or coldness regardless of the dry bulb or wet bulb temperature, or velocity of the air.

The relative humidity is the percentage of moisture actually present in the air as compared with the quantity which the air is capable of holding at the given temperature. As the temperature increases air can hold more water vapor. The relative humidity of air is lowered by a rise in temperature and increased by a lowering of temperature. Within certain limits at ordinary temperatures, an increase in comfort is experienced with an increase in the relative humidity. (See Table 8.) Below 46 degrees the reverse is true. Comfort is also affected by the movement of the air.

Results of Air Conditioning.—The effect of climate on health and as a factor influencing mental and physical aggressiveness is well known. Climate is weather over a long period, and to create and maintain proper atmospheric conditions indoors is the object of air conditioning. Adverse conditions are reflected in a decreased inclination and capacity for doing work. Good weather promotes good health, health promotes efficiency, and efficiency promotes production. "It has been found that even when men were urged to work they accomplished 28% less total work in a day in an atmosphere 86 degrees F., 80% relative humidity, than at 68 degrees F., 50% relative humidity."[2] J. I. Lyle, vice president of the Carrier Engineering Corporation, states that by providing a proper air supply, "In many instances the production is increased as much as 10% and in a few instances as much as 15% to 18% due to speeding up of

[1] Still air refers to an air movement not greater than 25 feet per minute.
[2] "Ventilation," New York State Commission on Ventilation, p. 196.

labor alone." Workers lose in physiological efficiency as air conditions vary from accepted standards. The effect may show itself in less output, in poorer workmanship, or both.

The effect of bad air upon appetite and growth is distinct and of obvious importance. Regarding this the New York Commission on Ventilation says: "Finally we found a marked influence exerted by stale air upon the appetite for food as determined by serving lunches to parallel groups of subjects in stale and fresh air, respectively, . . . the excess of food consumed under fresh air conditions was respectively, 4.4, 6.8, 8.6 and 13.6%." [3] Continued over a long period this would probably prove to be one of the most harmful effects of bad air.

The fact that workers will accustom themselves to unsuitable atmospheric conditions without protest does not minimize the harm done and should not be an excuse for their continuance. Weeks and even months may elapse before injurious effects demonstrate themselves. Fortunately, apart from the social considerations involved, the immediate effect upon production will usually pay dividends upon the cost of correcting the situation.

Where air conditions are favorable, it is noticeable that the zest for work on the part of employees increases, and more and better mental and manual work results as a natural consequence. It was this effect, observed in connection with installations designed primarily for process needs, that led to installations for the benefit of the personnel.

Business firms find that air conditioning results in a decrease of lost time due to illness of office employees of about 50%. Absences due to sickness have been estimated to average 7 days a year for men, and 9 days for women. Colds and similar disorders likewise contribute to inefficiency of workers on the job, so that the sum total of gain might be about one week's work or more per employee a year. The results in manufacturing departments would be greater where processes contaminate the air supply. In some cases absences have been decreased 90% following the installation of an air conditioning system. Physical and mental sluggishness is likewise an important cause of accidents.

Need for Air Conditioning.—Air conditioning is necessary in order to modify normal weather changes and conditions, to overcome vitiation of the air indoors due to crowding or industrial processes, to provide for a lack of natural ventilation, and to facilitate or make possible the carrying on of industrial processes affected by certain atmospheric conditions.

[3] *Ibid.*, p. 198.

The adverse effects which may be experienced because of bad air are: (1) headache, (2) mental lassitude, (3) physical and mental sluggishness, (4) fatigue, (5) cold, (6) excessive warmth, (7) abnormal reaction of the mucous membranes of the nose and throat, with resulting nervousness or susceptibility to infection, (8) unpleasant odors, and (9) decreased appetite. These effects result in a diminished capacity for doing work. Continued exposure to these conditions brings about a lowering of mental and physical vigor. Production costs become greater.

Air may be deficient as regards (1) temperature, (2) humidity, (3) carbon dioxide content, (4) presence of dust or fumes, (5) presence of bacteria, (6) odors, and (7) lack of movement. Standards have been formulated which are designed to eliminate these possible adverse conditions.

Standards of Air Conditioning.[4]—The accepted standards of air conditioning are:

1. Effective air supply—the proper introduction, distribution, and disposal of an adequate quantity of air.
2. Effective air temperature—considering temperature, humidity, and motion of the air.
3. Air cleanliness.
4. Air sanitation.
5. Odors.
6. Other injurious substances.

The injurious effect of bad air was formerly thought to be due in part to the depletion of the oxygen content, and to an increase in the carbon dioxide present. However, research and experiment indicate that any possible changes in these respects which may occur in workplaces are of little direct importance. Odors may prove disagreeable, causing discomfort, and thus affect well-being. The same is true of dusts, fumes, and gases, some of which may also be toxic or otherwise harmful in their effect. Some bacteria are injurious. As a general rule, however, the important factors of an air supply are its temperature, humidity, and circulation so that the body may rid itself of excess heat through the skin.

Industrial ventilation systems have been frequently designed to supply 3,000 cubic feet of air per hour per occupant, but this may and should vary, depending upon conditions. 1,200 cubic feet per hour may suffice in some areas, while air changes every three or four minutes in such

[4] "Modern Trend in Science of Ventilation," by Perry West, *Journal of the American Society of Heating and Ventilating Engineers*, Vol. 30, No. 6, pp. 421–438.

places as laundries, kitchens, boiler and engine rooms, galvanizing rooms, dye-rooms, etc., may be needed. The quantity of air introduced should be governed by the amount needed to maintain the quality standard.

As the temperature of air is increased beyond the comfort zone the relative humidity percentage should become lower in order that the evaporative effect on the body may be increased. (See Table 7.) Considering health and comfort, the relative humidity should be maintained between 35% and 70%, at a figure which in combination with the desired thermometer reading will give an ideal wet bulb reading of from 57 to 60.[5] The vapor content of the air may also be taken as a partial measure of its quality.[6] A content of from 4 to 5 grains per cubic foot is considered satisfactory with a permissible variation between 3 and 7 grains for a part of the time.[7] A vapor content of four grains gives a relative humidity of 60% at 64 degrees F., 50% at 70 degrees, and with a wet bulb of 56 and 59, respectively. Air must be comfortable to work in and this standard is expressed in "effective temperatures" coming within the "comfort zone" as determined by tests. Thus air, in order to satisfy the requirements of health, comfort, and working efficiency, must offer a proper combination of temperature, humidity, wet bulb reading, moisture content, and effective temperature.

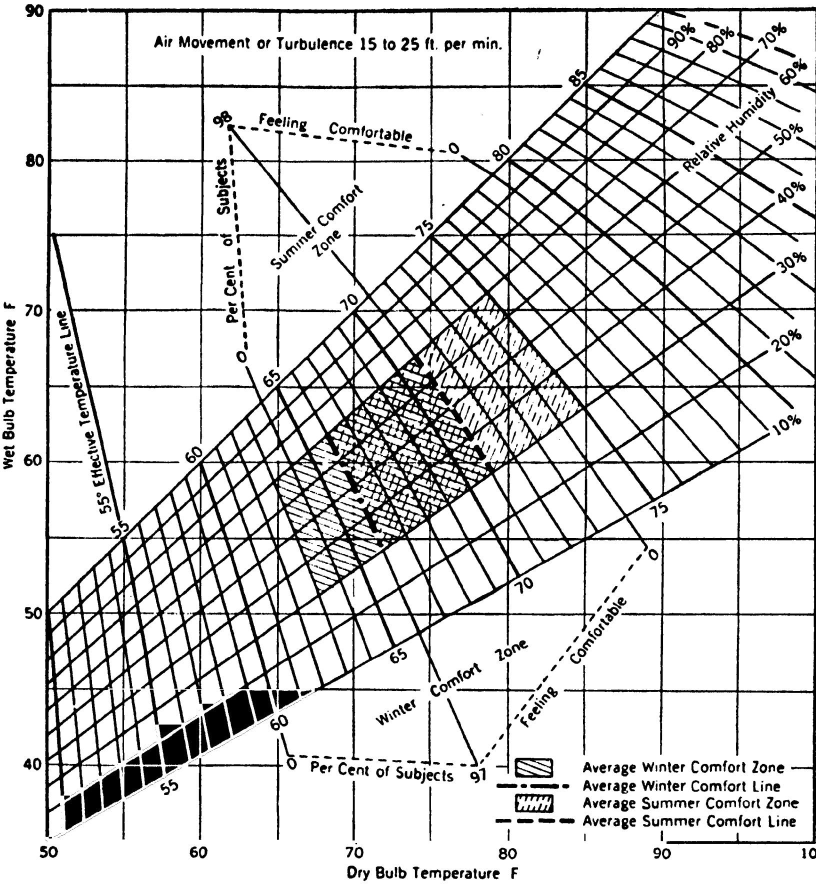
Table 7 was prepared from the comfort chart shown in Figure 84 and from other data. It shows the resultant wet bulb readings, vapor content, and effective temperature of air with various combinations of temperature and moisture content and at different velocities. The degree to which each of these combinations satisfies the specifications suggested in the preceding pages may be noted. In this respect it is well to remember that nature does not offer the same combinations at all times, and that variability is an essential to an invigorating climate. Although the air conditions in the office or plant may not vary appreciably, change is experienced during non-working hours outside.

[5] Wet bulb readings ranging between 48 and 66 do not result in abnormal death rates, but maintenance of the condition suggested above will tend to reduce the death rate below normal.

Other conditions permitting, relative humidity percentages of from 40% to 60% will ordinarily be used. In a temperature of 90 degrees and a relative humidity of 30% four times more work was performed than in air at the same temperature and 100% relative humidity. Five times more work was performed in a temperature of 90 degrees, relative humidity 60%, than in a temperature of 120 degrees and the same relative humidity. Work could be performed efficiently in air of 100 degrees F. and a relative humidity of 30%. ("Still and Moving Air," by W. J. McConnell and C. P. Yaglogou, *Journal of A. S. H. V. E.*, Vol. 31, No. 1, pp. 59–70.)

[6] "The least number of deaths occur in Boston hospitals when the temperature is between 61 and 70 degrees F. The humidity, 5.1 to 5.5 grains." ("Air Control as a Means of Reducing the Postoperative Death Rate," by Ellsworth Huntington, *American Journal of Surgery*, Anesthesia Supplement, Vol. 35, No. 7, pp. 82–90.) The least number of postoperative deaths per day occurred when the vapor content was between 3.6 and 4.0 grains. (*Ibid.*, Vol. 35, No. 10, pp. 98–100.)

[7] The less moisture, the lower the dew point, and consequently lower possible temperature of walls without condensation.



(Courtesy A. S. H. V. E.)

Figure 84. A. S. H. V. E. Comfort Chart for Air Velocities of 15 to 25 FPM (Still Air)

Both summer and winter comfort zones apply to inhabitants of the United States only. Application of winter comfort line is further limited to rooms heated by central station systems of the convection type. The line does not apply to rooms heated by radiant methods. Application of summer comfort line is limited to homes, offices and the like, where the occupants become fully adapted to the artificial air conditions. The line does not apply to theaters, department stores, and the like where the exposure is less than 3 hours.

During the summer months it is found that a maximum difference of about 15 degrees is permissible between indoor and outdoor conditions. One company increases an indoor temparature of 72 degrees one degree for each rise of three degrees in the outdoor temperature above 70 degrees. With an outdoor temperature of 100 degrees the indoor reading would be 82 degrees. Too great a contrast will prove disagreeable and may cause illness.

Table 7. Effective Air Temperatures at Varying Velocities Under Different Thermometer Temperatures and Humidities

Temp. Fahr.[1]	Rel. Hum.[2]	Dew Point[3]	Outdoor Temp.[4]	Wet Bulb[5]	Grains of Water Vapor[6]	Effective Temperatures at Various Velocities per Minute[7]			
						Still Air	100′	300′	500′
75	100	75.0	75.0	75.0	9.4	75.0	73.2	69.8	67.3
	70	64.4	61.0	67.9	6.6	71.8	70.2	67.2	65.0
	60	60.0	55.0	65.3	5.6	70.9	69.3	66.4	64.4
	50	55.0	48.0	62.6	4.7	70.0	68.5	65.7	63.8
	40	48.5	39.0	59.8	3.8	69.1	67.6	65.0	63.2
	30	41.1	28.0	56.6	2.8	68.2	66.9	64.4	62.7
	20	30.1	15.0	53.2	1.9	67.4	66.1	63.7	62.2
70	100	70.0	70.0	70.0	8.0	70.0	68.0	63.8	61.0
	90	67.0	66.0	67.9	7.3	69.1	66.9	63.1	60.5
	85	65.2	64.0	66.8	6.8	68.7	66.7	62.7	60.2
	80	63.5	61.0	65.8	6.4	68.3	66.3	62.4	60.0
	70	59.5	56.0	63.4	5.6	67.5	65.5	61.8	59.5
	60	55.2	50.0	61.0	4.8	66.7	64.9	61.4	59.0
	50	50.2	43.0	58.5	4.0	66.0	64.3	60.9	58.6
	40	44.4	36.0	55.9	3.2	65.3	63.6	60.4	58.3
	30	36.7	26.0	53.0	2.4	64.7	63.0	60.0	57.9
	20	27.3	13.0	50.0	1.6	64.0	62.5	59.5	57.7
68	100	68.0	68.0	68.0	7.5	68.0	65.7	61.2	58.3
	90	65.0	64.0	66.0	6.8	67.2	65.0	60.7	58.0
	85	63.0	61.0	65.0	6.4	66.8	64.7	60.4	57.8
	80	61.5	59.0	63.9	6.0	66.4	64.2	60.2	57.6
	70	57.5	54.0	61.6	5.3	65.7	63.7	59.7	57.3
	60	53.2	48.0	59.2	4.5	65.0	63.0	59.3	56.9
	50	48.5	42.0	56.9	3.8	64.5	62.5	58.8	56.6
	40	42.4	34.0	54.3	3.0	63.8	62.0	58.5	56.3
	30	35.0	24.0	51.3	2.3	63.2	61.4	58.0	55.9
	20	25.7	11.0	48.6	1.5	62.6	60.9	57.7	55.6
66	100	66.0	66.0	66.0	7.0	66.0	63.6	58.9	55.9
	90	63.0	62.0	64.0	6.4	65.3	63.0	58.3	55.5
	85	61.3	59.0	63.0	6.0	65.0	62.6	58.1	55.4
	80	59.5	57.0	62.0	5.7	64.7	62.3	57.9	55.2
	70	55.6	52.0	59.8	5.0	64.0	61.7	57.5	54.9
	60	51.4	46.0	57.5	4.2	63.4	61.2	57.1	54.6
	50	46.9	41.0	55.2	3.5	62.8	60.7	56.8	54.3
	40	40.8	32.0	52.8	2.8	62.2	60.2	56.5	54.1
	30	33.2	22.0	50.1	2.1	61.7	59.8	56.2	53.9
	20	24.3	10.0	47.3	1.4	61.1	59.4	55.9	53.7
64	100	64.0	64.0	64.0	6.6	64.0	61.3	56.3	53.1
	90	61.0	60.0	62.1	6.0	63.4	60.8	56.0	52.9
	85	59.4	58.0	61.1	5.6	63.0	60.6	55.8	52.8
	80	57.5	55.0	60.1	5.3	62.8	60.3	55.7	52.7
	70	54.0	51.0	58.0	4.6	62.2	59.9	55.3	52.6
	60	49.7	45.0	55.8	4.0	61.7	59.4	55.0	52.2
	50	45.0	39.0	53.6	3.3	61.1	58.9	54.7	52.1
	40	39.0	31.0	51.1	2.6	60.7	58.6	54.5	52.0
	30	31.7	21.0	48.5	2.0	60.2	58.2	54.3	51.9
	20	23.0	9.0	46.0	1.3	59.7	57.8	54.0	51.7
62	100	62.0	62.0	62.0	6.1	62.0	59.0	53.9	50.5
	90	59.1	57.0	60.2	5.6	61.4	58.7	53.6	50.3
	85	57.2	55.0	59.2	5.3	61.1	58.4	53.5	50.2
	80	55.7	54.0	58.3	5.0	60.9	58.2	53.2	50.2
	70	52.2	49.0	56.1	4.3	60.4	57.9	53.0	50.1
	60	47.9	43.0	54.0	3.7	60.0	57.5	52.9	50.0
	50	43.0	37.0	52.0	3.1	59.6	57.2	52.7	50.0
	40	37.0	29.0	49.6	2.5	59.1	56.8	52.5	49.9
	30	30.0	19.0	47.1	1.9	58.7	56.5	52.3	49.8
	20	21.8	8.0	44.7	1.2	58.3	56.2	52.1	49.6

TABLE 7. (Continued)

Temp. Fahr.[1]	Rel. Hum.[2]	Dew Point[3]	Outdoor Temp.[4]	Wet Bulb[5]	Grains of Water Vapor[6]	Effective Temperatures at Various Velocities per Minute[7]			
						Still Air	100′	300′	500′
60	100	60.0	60.0	60.0	5.7	60.0	55.9	51.3	47.8
	90	57.0	56.0	58.2	5.2	59.6	55.5	51.1	47.8
	85	55.3	54.0	57.3	4.9	59.3	55.4	51.0	47.8
	80	53.9	52.0	56.4	4.6	59.1	55.2	51.0	47.8
	70	50.1	47.0	54.3	4.1	58.7	55.9	50.9	47.8
	60	46.0	41.0	52.2	3.5	58.3	55.6	50.7	47.7
	50	41.2	35.0	50.3	2.9	57.9	55.4	50.6	47.7
	40	35.2	27.0	48.0	2.3	57.5	55.2	50.4	47.7
	30	28.9	18.0	45.8	1.7	57.2	54.9	50.3	47.6
	20	20.0	7.0	43.3	1.1	56.9	54.6	50.2	47.6
56	100	56.0	56.0	56.0	5.0	56.0	52.4	46.2	42.4
	90	53.3	52.0	54.3	4.6	55.7	52.2	46.2	42.5
	85	51.5	50.0	53.4	4.3	55.5	52.2	46.2	42.6
	80	50.1	48.0	52.6	4.0	55.4	52.1	46.2	42.7
	70	46.2	43.0	50.8	3.5	55.1	51.9	46.2	42.8
	60	42.4	38.0	48.8	3.0	54.9	51.8	46.2	42.9
	50	38.0	32.0	47.0	2.5	54.7	51.7	46.2	43.0
	40	32.0	24.0	45.0	2.0	54.4	51.5	46.2	43.1
	30	25.0	14.0	42.9	1.5	54.1	51.3	46.2	43.2
	20	17.0	4.0	40.8	1.0	53.9	51.2	46.2	43.2

EXPLANATION OF TABLE

1. The usual temperature range for health and comfort is between 60 and 72 degrees F. In some instances higher temperatures might be preferable in order to avoid too great a contrast between outdoor and indoor conditions. A condition of comfort can be maintained even at much lower or higher dry bulb temperatures by properly controlling the humidity and velocity of the air.

2. The humidity percentages should vary somewhat according to the temperature, in general being lower at high temperatures and vice versa, ranging from 35 to 40% to 70 or possibly 80 in some cases. For summer comfort indoor temperatures should be raised in order to avoid too great a contrast with outdoor conditions as explained elsewhere. A condition of comfort can be maintained with lower or higher relative humidity percentages by properly controlling the temperature and velocity of the air.

3. Temperatures on inside of glass resulting from other conditions stated. The temperature at which condensation would take place. With high relative humidity percentages indoors and low temperatures outdoors, glass and wall area temperatures may easily be so low as to cause objectionable condensation. This reason combined with the difficulty of evaporating sufficient water is why in house heating the humidity of the air is usually below 25%, frequently only from 12 to 20%.

4. These or lower temperatures outdoors, with corresponding dry bulb and relative humidity readings would result in glass temperatures (inside of windows) as indicated under "dew point," and condensation would result.

5. Wet bulb readings may vary between 48 and 66, ideal readings coming between 57 and 61, the higher figure being preferable for the summer months when less clothing is worn. The effect of wet bulb readings on comfort may be modified by properly controlling the velocity of the air.

6. The usual water content should probably be from four to five grains, with permissible variations between three and seven grains per cubic foot of air. (See footnoes 6 and 7.)

7. Effective temperature readings between 63 and 71 come within the comfort zone considering individuals normally clothed and at rest in still air. These are slightly lower for persons who are active. (See Figure 84 and 85.)

Research at the University of Illinois indicates that maximum comfort is attained at 70 degrees with 50% relative humidity. With humidity cut to 20% the temperature must be raised to 73 degrees for the same amount of comfort. In cold weather it may not be possible to maintain desirable relative humidities without objectionable condensation upon cold windows or other exposed surfaces. Double windows and insulated walls overcome this difficulty.

Obtaining Cooling Effects.—Cooling effects may be obtained by (1) lowering the dry bulb temperature of air, (2) reducing its moisture content, (3) air circulation, and (4) adding moisture to the air without heat. In (2) by reducing the moisture content, the evaporative effect is increased, and in (4) by adding moisture the temperature is lowered. The method chosen will depend upon local conditions, which will give desired results at least cost.

Air in motion at ordinary temperatures is cooling in its effect, and to a greater degree as its velocity is increased. Velocities up to 300 feet per minute are more efficient than higher velocities.[8] The effective temperature difference between still air and moving air is greater at high humidities than low humidities. These facts are apparent by reference to Table 7 and Figure 85. As long as the wet bulb temperature of the air is below the body temperature a cooling effect is exerted, but when above, an opposite effect is felt.

It is frequently possible to secure a considerable cooling effect by providing simple and inexpensive equipment to put the air in motion, but if the air temperatures are high, this remedy is less effective. At high temperatures, the cooling effect of air even at high velocities is small, and it may prove economical first to saturate the air, thus reducing its temperature, in order to get greater effect. If the air is dry, or there is considerable difference between the wet bulb and dry bulb temperatures, the cooling effect by air washing is greater than if the air has initially a greater moisture content.

The Thermometric Chart.—The thermometric chart (Figure 85) is described thus:

> . . . affords a complete formulation of the laws of cooling of the human body. The proximity of any point to the dry and wet bulb axes indicates the superiority of one temperature over the other in determining human comfort. For ordinary temperatures the points are nearer to the dry bulb axis, while for high temperatures, when sensible evaporation

[8] In practice velocities greater than 300 feet per minute are seldom used.

comes into play, the upper part of the diagram approaches the wet bulb axis . . .

It will be observed that in the lower part of the diagram the various velocity lines intersect the dry bulb axis at temperatures at which the effect of wet bulb, or humidity of the air, is eliminated completely. Below these temperatures the divergence of the velocity lines away from the dry bulb axis and the change in their curvature indicate a reversal in the effect of humidity; the higher the humidity the cooler the condition, and vice versa.

At high temperatures the velocity curves converge toward each other, until at body temperature they all meet at a common point called the "neutral point" in atmospheric conditions. Above this point the reversal in the order of the velocity curves with reference to the still-air curve shows the heating effect of wind upon the human body, and its increase with velocity.

. . . The distance between any two consecutive velocity lines is a function of the amount of cooling produced by an increase of 100 feet per minute in the velocity of the air. Above 300 feet per minute the efficiency of air movement falls off considerably, and it will be inefficient in practice to use velocities greater than this.[9]

The following example illustrates the use of the chart: Given dry bulb 76 degrees, wet bulb 62 degrees, velocity of air 100 feet per minute, determine:

1. Effective temperature of the condition.
2. Effective temperature with still air.
3. Cooling produced by the movement of the air.
4. Velocity necessary to reduce the condition to 66 degrees, effective temperature.

Procedure:

1. Draw line A–B through given dry and wet bulb temperatures. Its intersection with the 100-foot velocity curve gives 69.0 degrees for the effective temperature of the condition.
2. Follow line A–B to the right to its intersection with the 0 velocity line, and read 70.4 degrees for the effective temperature with still air.
3. The cooling produced by the movement of the air is 70.4 − 69.0 degrees = 1.4 degrees effective temperature.
4. Follow line A–B to the left until it crosses the 66-degree effective temperature line. Interpolate velocity value of 340 feet per minute, to which the movement of the air must be increased for maximum comfort.

[9] "Effective Temperature with Clothing," by C. P. Yaglogou and W. Edw. Miller, *Journal of A. S. H. V. E.*, Vol. 31, No. 1, pp. 59–70.

By passing this air through a humidifier where the water is recirculated and not heated, the dry bulb temperature will be reduced to 62 degrees, the wet bulb temperature. A line connecting the two 62-degree points on the respective scales will pass through the effective temperature

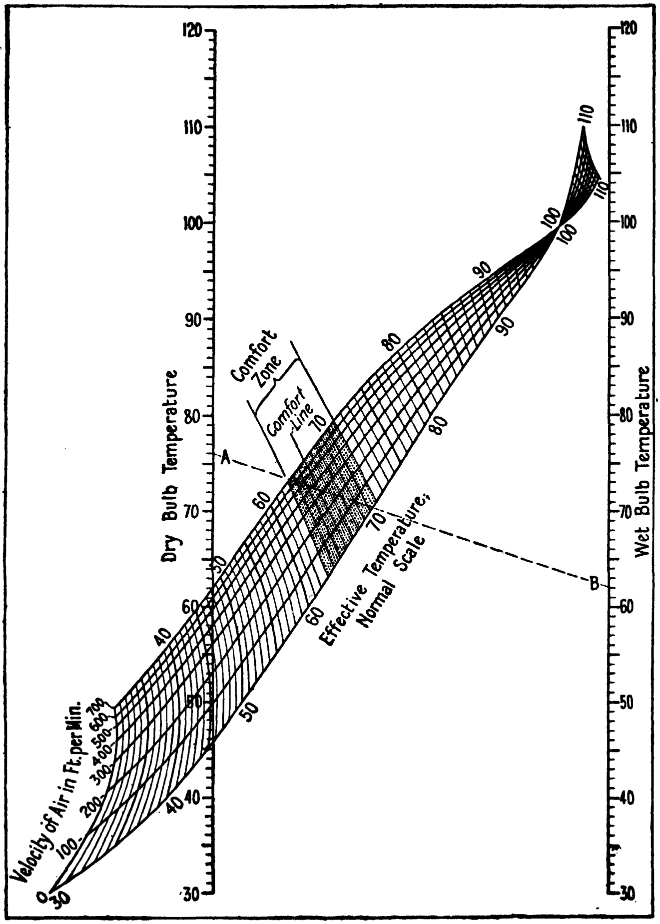


Figure 85. Thermometric Chart

Developed by C. P. Yagloglou and W. Edw. Miller for human beings at rest and normally clothed. A. S. H. V. E. Research Laboratory in co-operation with the Bureau of Mines.

line at 62 degrees which is 8.4 degrees lower than before. The cooling effect of moving the air at a rate of 100 feet per minute will then be 3.0 degrees as compared with 1.4 degrees previously. When air at high temperatures and low or moderate humidities can be treated in this manner there is considerable advantage in doing so.

For an effective temperature of 65 degrees, and with 20% relative humidity, the wearing of normal clothing requires a lower dry bulb temperature by 3.3 degrees, than when subjects are stripped to the waist. This difference decreases as the effective temperature rises, until at 94 degrees it is immaterial whether clothing is worn or not. At still higher temperatures clothing is an aid to cooling. Therefore, in industrial operations that require exposure to high temperatures and low humidities workers will be better off if their entire body is covered with clothing.[10]

Industrial Uses of Air Conditioning.—The first silk mill in England was also the first to attempt air conditioning. Of this plant, erected in 1719 near Derwent, Charles Knight wrote: "One fire-engine conveys warm air to every part of this vast machine (which produced silk yarn)." [11]

However, air washing and humidifying equipment making possible the control of the moisture content and cleanliness as well as the temperature has only been available during the present century. During this period rapid progress has been made in the science of air conditioning and the design of equipment to give automatic and absolute control of atmospheric conditions. Air control is now practised in over a hundred industries, and the effect of natural climate on materials is thus eliminated. It often saves time and production space, assures the quality and purity of the product, and makes possible standard production schedules.

Each industry and each plant presents problems calling for careful individual consideration of all the influencing factors. Climate, surroundings, product, raw materials, processes, and the physical plant have their effects on the atmosphere. The degree of control effected will vary with the materials, the products, and the results desired. Some accomplishments in this field will serve to illustrate present engineering practice and the industrial possibilities.[12]

In candy making the air must be clean and pure, thoroughly distributed, cool, and relatively dry. The confectioner may then avoid "gray chocolates," stickiness, lack of a glossy finish on hard candies, etc. Quality and appearance are vital to sales success. (See Figure 86.) A porcelain sanitary maker increased his plant capacity 125%, decreased quantity of stock in process 74%, and reduced the production time of one drying operation from an average of 17 to 21 days to 18 hours. Faulty

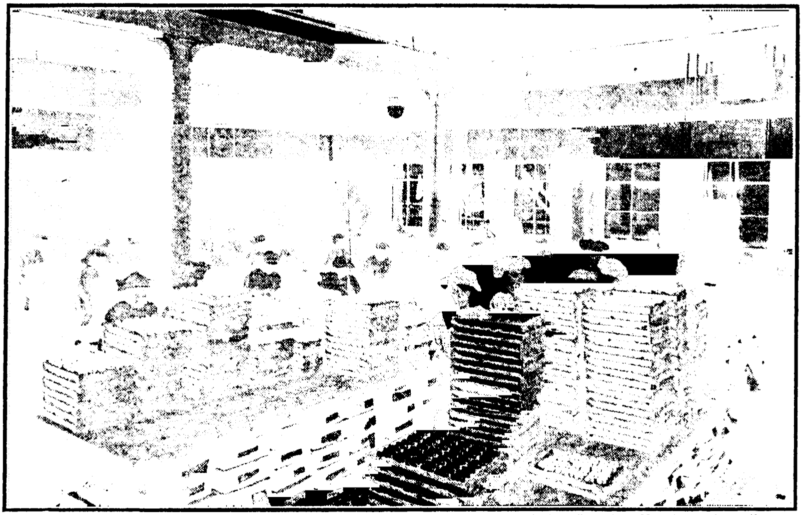
[10] Heat losses occur due to radiation, convection, and evaporation. As the body temperature is approached, those by radiation and convection approach zero, while due to perspiration, the evaporative heat losses increase and are made greater by the greater area of clothing surface as compared with body surface.

[11] Old England, by Charles Knight, Vol. 2, p. 323.

[12] The writers are indebted to the literature of the Carrier Engineering Corporation for much of this descriptive material.

pieces were practically eliminated by the uniformity and dependability of control. "Manufactured weather dries any material at maximum speed because it is automatically adjusted to meet the exact requirements of the given material at the given instant in its drying progress. . . . The control device is equipped with a timing mechanism which automatically alters the temperature and humidity at fixed intervals of time, from the beginning to the end of the drying process." [13]

In cotton manufacture, if the fibres are too dry they are brittle and easily broken. If too wet they are easily pulled apart, easily stretched



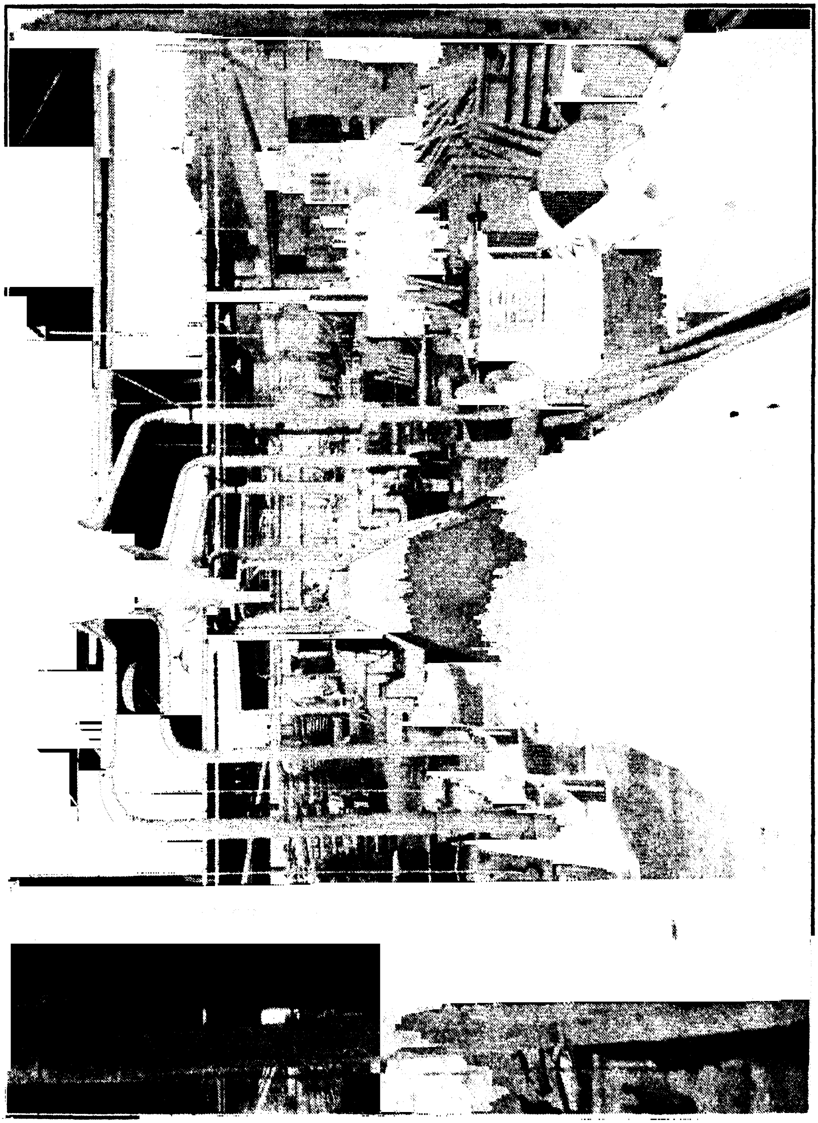
(Courtesy of the Carrier Engineering Corp.)

Figure 86. View in the Whitman Chocolate Company Plant

beyond their elastic limit and weakened. Control of the temperature and humidity within definite limits is essential to quality and quantity output of cotton, wool, and silk goods. Paper, like textiles, involves the treatment of fibres. Thus moist paper is weaker in tensile strength than dry paper; and the quality of the printed impression is greatly affected by the room temperature and moisture content of the paper.

Makers of fine wood furniture, likewise, need to maintain uniform and favorable air conditions throughout their plants. Strength of glued joints, workmanship, and finish, depend on it. Exhaust systems are used to remove dust, smoke, or fumes from operations or processes and thus keep the air in the workplace clean.

[13] "The Weather Vane," Carrier Engineering Corporation, Vol. 3, No. 3, p. 22.



(Courtesy of The Lamson Co.)

Figure 87. Duct System for Dust Removal by Air Suction

Air conditioning enables the baker to control the processes in his plant, something which is essential to standardization and uniformity of product. Specialists have discovered that the process of dough fermentation is best carried on at a temperature of 80 degrees F., and a relative humidity of 80%. Ordinarily, the fermentation period may take 5 or 6 hours; with controlled air conditions, a maximum of 3 hours. Further, with unconditioned air, fermentation must frequently be forced, requiring more yeast and flour. When ideal conditions prevail as many as fifteen more loaves of bread are secured from each barrel of flour. Icings, frostings, and cake decorations are affected by too much moisture in the air. In the dough room air which is too dry will absorb moisture from the dough, causing crusting. Unsightly lumps appear, fermentation practically ceases, blow holes form, and the final product is deficient in appearance and taste. The removal of dust and impurities from the air is an important factor in sanitation. Many food product plants desire that their goods reach the consumer crisp and appetizing, and this object is attained by atmospheric control in the factory in combination with delivery in sealed containers. Drugs, pharmaceutical and biological products, surgical and hospital supplies need to be prepared and packaged in conditioned air for obvious reasons.

The manufacture of airplanes on a quantity basis calls for controlled atmosphere. Engine parts are made to very close tolerances. Even natural light falling on the work may cause changes in temperature sufficient to make the parts inaccurate. The manufacture of watches and fine machinery, and the use of delicate equipment necessitate air free from dust and moisture. Automatic machinery is often dependent upon an unvarying state of the materials it handles if it is to function satisfactorily, as in gum making and wrapping. The presence of static electricity interferes with many machine operations and is usually indicative of low relative humidities. It may be eliminated by increasing the moisture content. Perspiration on the hands of those packing polished metal objects may cause tarnishing. The remedy is to reduce the moisture content of the air.

Not only are materials improved but machinery, particularly electrical equipment, operates more smoothly and with less wear when the air supply is properly tempered and clean. As a consequence it lasts longer. In countless ways in innumerable industries from gum to automobiles and aeroplanes, artificial weather may aid in producing cheaper and better products.

The benefit afforded the workers may often be of equal or greater importance. The "human machine" rather than the "iron man" wields

TABLE 8. PROPER TEMPERATURES AND HUMIDITIES FOR VARIOUS INDUSTRIAL PROCESSES

The following tabulation of favorable conditions of temperature and humidity for a wide variety of processes and products, is presented primarily to demonstrate the wide departure from uncontrolled weather and the variety of conditions which may be demanded, even within a single plant.

INDUSTRY AND PRODUCT	PROCESS	TEMPERATURE DEGREES F.	PER CENT RELATIVE HUMIDITY
BAKERIES	Dough Fermentation	80	80
	Proofing	90 to 95	80 to 90
	Bread Cooling	70	65 to 70
PREPARED CEREALS AND BEVERAGE POWDERS	Packaging and Sealing	75	40 to 45
CHEWING GUM	Rolling and Scoring	75	50
	Wrapping and Packing	70	45
CONFECTIONS	Enrobing and Hand Dipping	65	55
	Hard Candy Cooling and Packing	70	40
	Starch Room	75 to 85	50
	Packing	65	50
DAIRY PRODUCTS	Butter Making	60	60
	Chill Room	40	60
BUTTER SUBSTITUTES	Churn Room	70	60
	Print Room	60	60
	Chill Room	30	60
MEAT	Bacon Slicing	60	45
BANANAS	Holding Ripe Fruit	56	70 to 75
	Holding Green Fruit	58	70 to 75
	Slow Ripening	60 to 62	90
	Fast Ripening	70 to 72	90
TOBACCO	Softening	90	85
	Stemming or Stripping	75 to 85	70
	Cigar and Cigarette Making	70 to 75	55 to 65
PRINTING AND LITHOGRAPHING	Press Room	70 to 80	Winter—45 Summer—55
	Folding	70 to 80	65
	Binding	70 to 80	45
LACQUERING	Spray Room	75	25
COTTON	Carding	75 to 80	50
	Combing	75 to 80	60 to 65
	Roving	75 to 80	50 to 60
	Spinning	75 to 80	60
	Long Draft	75 to 80	50 to 55
	Short Draft	75 to 80	60 to 65
	Spinning	75 to 80	60
	Twisting and Spooling	75 to 80	65
	Warping	75 to 80	65
	Weaving	75 to 80	75 to 80
WOOL	Carding	75 to 80	65 to 70
	Spinning	75 to 80	55 to 60
	Weaving	75 to 80	50 to 55
SILK	Dressing	75 to 80	60 to 65
	Spinning	75 to 80	65 to 70
	Throwing	75 to 80	65 to 70
	Weaving	75 to 80	60 to 70
RUBBER	Dipping Surgical Rubber Articles	75 to 80	25 to 30
	Standard Laboratory Tests	82 to $\pm$2	45 to $\pm$3
DRUGS	Effervescent Powders and Tablets	70 to 80	30 to 35
FILMS	Drying Negatives	75 to 80	50
MOTION PICTURES	Drying Positives	75 to 80	50
	Printing Room	70	70
	Cutting Room	72	65

(Courtesy of Parks-Cramer Company, Fitchburg, Mass.)

the chief influence in increasing output and lowering costs in many industries. The International Business Machines Corporation installed air conditioning in the engineering laboratory and offices with the result that more new products were designed and more production secured at less cost than previously. Invigorating weather—the year around—keeps minds and bodies thoroughly "alive," creating energy, enthusiasm, and good nature, the driving forces of industry.

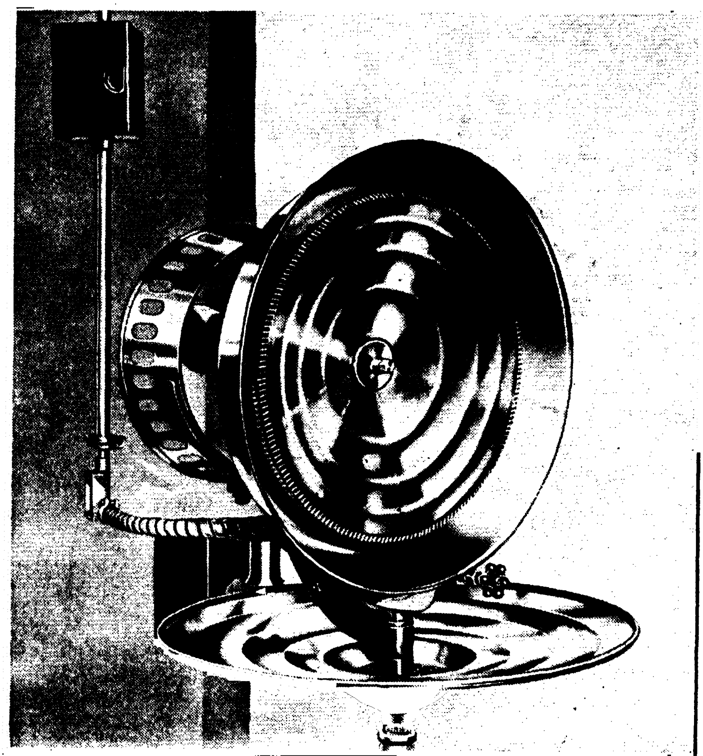
The list of favorable conditions of temperature and humidity for a diversity of processes and products, shown in Table 8, demonstrates the wide departure from uncontrolled weather and the variety of conditions which may be demanded, even within a single plant.

Ventilating Equipment.—There are several methods of bringing in and circulating fresh air which are more or less effective depending upon conditions. These ventilating systems are readily classified as either natural or mechanical systems. In the former the normal movements of air currents are utilized; sometimes made more positive and accelerated by mechanical devices. The latter systems utilize mechanical equipment to pull the air into the plant, and then to distribute it where wanted. The slightly increased atmospheric pressure brought about by the constant introduction of a large volume of fresh air causes an outflow of air through windows and openings. Or exhaust fans and ducts may be used to remove the bad air.

Window ventilation under favorable climatic and weather conditions may prove adequate in workrooms where the number of employees is limited, where vitiation of the air supply is not a problem and where the effect of the atmosphere on materials is not a factor. Fresh air enters and is tempered by the heat from radiators or by mixing with the air supply in the room. Inattention to window ventilation results in no ventilation. Likewise cold, rain, or snow affects the supply of air from such sources and renders them ineffective. The workers who are nearest the windows may be too cold, others too warm. In any event, the humidity, purity, and circulation of the air are not controlled by window ventilation, and the temperature is controlled only partially. Window ventilation may be improved by providing a means of escape for the used air in the room through ducts. The natural movement may be increased and the circulation in the room improved by placing aspirating coils in the ducts, or by using exhaust fans. In small workshops and for particular workplaces a cooling effect may be obtained by using a local fan system to blow a current of air upon those employed.

Exhaust fans placed in outside walls may be used in conjunction with window ventilation to effect air changes. They are effective in removing

odors, steam, fumes, gases, heat, etc., from laundries, kitchens, galvanizing rooms, and heat-treating departments. Their effectiveness decreases as the room area is increased, and when opposing currents of air are set in motion. The local application of the exhaust or vacuum principle is very common and useful. Hoods are placed at the points of origin of dust, smoke, heat, etc., and the objectionable elements are drawn directly



(Courtesy of The Bahnson Co.)

Figure 88. A Bahnson Unit Humidifier

into the hoods and removed, thus preserving the purity of the air in the room.

Ventilators placed on the roofs of buildings afford outlets through which heated air may escape. Natural chimney action is greatly increased because of the convection currents set up in the ventilators by wind currents across their tops; thus bad air is pulled out of the building. This equipment is effective in heat and drop forging plants, paper mills,

boarding departments of hosiery mills, in the textile industry, boiler and engine rooms, etc. Ventilator efficiencies may be decreased by absence of wind movement, by cross currents of air in the building, or by an insufficient inflow of fresh air.

Humidification may be accomplished by use of unit humidifiers. These are suspended at intervals from the ceiling or mounted on columns, and give off a very finely divided water spray which the air absorbs, the degree of humidity being controlled by hygrometers. The temperature of the feed water may be varied, but insufficient control of temperature

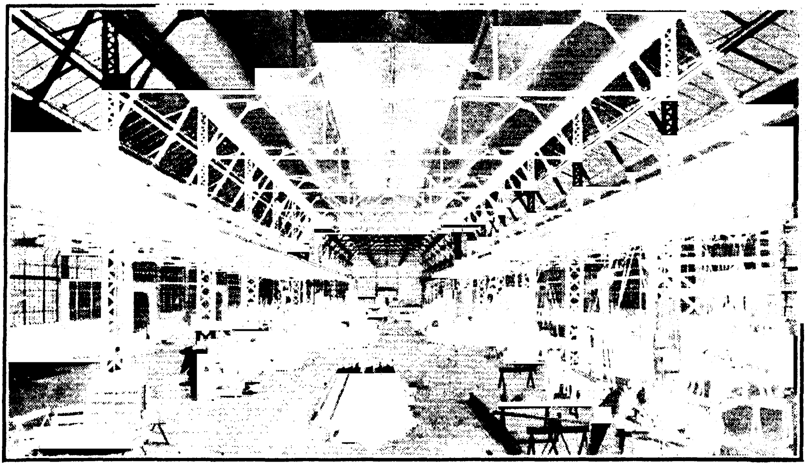


Figure 89. This Flat Roof Monitor Gives Perfect Light and Ventilation. Plant of Richards-Wilcox Manufacturing Company, Aurora, Illinois

during the summer months may cause discomfort or affect the workability of materials. Figure 88 shows this type of equipment.

Natural ventilation systems are particularly applicable to a certain class of industrial buildings in the metal trades known as heat-producing buildings. These comprise steel mills, tube mills, foundries, forge shops, core rooms, and sometimes machine shops, and constitute a large industrial group where the worst conditions are quite likely to obtain on account of the high temperatures, smoke, gases, fumes, and dust constantly being produced.

Figure 89 shows a flat-roof monitor which gives excellent light and ventilation. "Runs" of sash in monitor and side walls are motor-operated en masse. Single sashes in side walls are hand-regulated.

The M-shaped roof truss provides a much larger area of roof opening than the ordinary monitor, and the roof slopes are designed to lead the

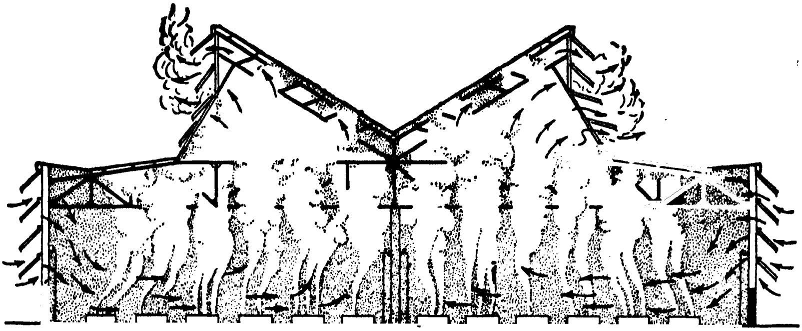


Figure 90. Cross-Section of a Typical Foundry with M-Shaped Roof Truss

air naturally to and through the outlets. Masses or "runs" of controlled sash are also built in the side walls of the building to provide air inlets. In the building shown in Figure 90, natural currents keep the air clear. Gases and heat will escape against a light wind if the lower "runs" of outlet sash on the windward side are closed as shown. Figure 90 provides an excellent example of M-shaped roof trusses and side wall sash used for natural ventilation.

When large floor areas are to be ventilated air may be drawn in through A-frames built in the roof. Natural air movements may be supplemented by the installation of fans and a duct system which bring in outside air and release it through a series of outlets a few feet above

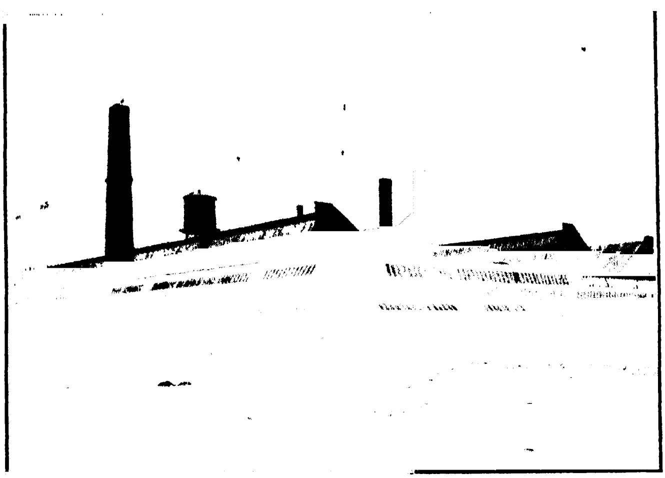


Figure 91. Moline Malleable Iron Company Foundry, St. Charles, Illinois

the floor level, thus increasing the supply of fresh air, circulation, and removal of smoke, heat, dust, and fumes.

In order to obtain clean air the incoming supply may be drawn through filtering devices installed in the entrance to the duct system, and as much as 97% of the atmospheric dust, dirt, soot, and bacteria filtered out. The air is cleaned by impingement on and scrubbing contact with adhesive or oil-coated surfaces. Where oil is used it is allowed to flow downward over the vertical surfaces against which the air makes contact. The accumulated impurities are then filtered out and the oil recirculated. Such a cleaner will remove soot and smoke more effectively than air washers. This equipment probably provides the cheapest means of securing clean air, which is always desirable. However, it does not give control of the moisture content. Obviously air conditioning is not accomplished by any of the methods described above to a greater extent than removing the bad air and bringing in fresh outdoor air. In many instances, however, the successful accomplishment of this result provides a tremendous improvement over previously existing conditions at a small cost and may be all that is practicable.

Air Conditioning Equipment.—Absolute control of atmospheric conditions indoors is practically a necessity in many plants and this may be achieved by the installation of air conditioning apparatus in combination with a duct system for its distribution, and another for its removal if required. Air is drawn into the apparatus, washed, cleaned, and tempered as desired, then forced into the duct system for distribution. When the air enters the conditioning machine the spray water may be automatically maintained at a temperature which will take heat from the air, and thus reduce its moisture content. The result will be to dehumidify the air. The same equipment may be used as a humidifier by raising the temperature of the spray water so that it will convey heat to the air and increase its water content. Apparatus of this kind may be installed in a candy factory or any place where it is necessary to reduce the normal humidity of the air. In a textile mill, humidifying action would probably be needed together with temperature control. The benefits to be derived by manufacturing weather to fit production needs exactly, and to maintain healthful conditions for employees are more and more appreciated by employers.

Henry Ford and other industrialists have taken the lead in installing complete air conditioning equipment for foundries, heat-treating departments, and workplaces where heretofore only ventilation as suggested by Figure 90 was considered practical. In some cases as many as 25 cubic yards of dirt are removed from the air daily.

Electric Precipitators.—The Westinghouse Electric and Manufacturing Company has developed an electric precipitator which ionizes or charges the air. The ionized particles pick up virtually all dust in the circulating atmosphere, find their way to charge plates and deposit their burden of dirt. Tobacco smoke may be removed in this way. Installations are effective in minimizing dirt damage to fine linens, draperies, or other delicate merchandise, or to prevent silicosis caused by breathing certain mineral dusts. The use of ultra-violet rays for purifying the air supply is mentioned in the chapter on lighting.

Instead of proving an expense, these equipments should pay dividends on their cost and prove a valuable asset to the concern in keeping desirable, experienced employees on the job. Bad air is bad business.

CHAPTER 17

STANDARDIZATION AND SIMPLIFICATION

The Consumer and the Simplified Product.—In its broadest sense simplification is a philosophy which strictly discourages all unnecessary motions in business. It may be applied to commodities, methods, or activities. In business usage the term generally refers to the practice of reducing the variety of products made or sold by eliminating certain styles, sizes, or other diversifying qualities. Contrary to what is claimed by some sales-minded individuals it is not true that the consumer is fundamentally opposed to simplification. While differences in appearance or size are frequently valuable in promoting the sales of many products, for the most part merchandise today can be and is sold on the basis of its ability to fulfill the use to which it will be put. Together with the change from hand production to mass production in manufacturing there has been a change in the attitude of the consumer from a demand for originality, extremely complex styles, and the unique, to a demand for an article which is functional. It is noteworthy that neither simplification in manufacturing nor the demand of the consumer for functional items has resulted in a loss of aesthetic appeal in the product. At present, industry, through simplification, not only is producing more articles, but these articles are better and more beautiful as a result of their simplicity.

The objections to simplification which were voiced at the beginning of the era of mass production; namely, that the result would be a standardized and monotonous world, appear today to have been unfounded. The result has not been a monotonous world, but rather, a world in which the simplicity of design, and utility of the simplified articles serves as a basis for more variety in life itself. It is true that the early critics of mass production saw at once the logic in the process that would inevitably lead to simplified products; what they did not see was that these products would not be frozen in the designs then extant, but rather, that the possibilities of quantity production would serve as an inspiration for the development of new art forms peculiarly adapted to it.

Economies of Simplification.—The possibilities of economy inherent in present-day mechanical production comprise one of its greatest potential contributions to man's standard of living. Simplification, by allowing the natural efficiency of mechanical production full sway, elimi-

nates waste, decreases costs, and increases values in product distribution and consumption. The fact that, used in this way, simplification efforts result in a limited choice of articles is not a disadvantage provided manufacturers place the proper emphasis upon functional design and adaptability to use, and educate the consumers through advertising to the significance of the modern trend toward finding value and beauty in utility. This is the common ground for the consumer and for the producer of large quantities. Wherever a meeting on this common ground can be arranged by suitable sales techniques and education, the benefit to man is real. The lower price possible through simplified quantity production inevitably raises the general standard of living. It should be remembered that this lower price results not only through increased economies in production, but also through increased economies in distribution.

In a western city 82 brands of coffee were offered for sale, although 71% of sales were of seven brands. One hundred and thirty-seven brands of talcum powder were available, with 60% of the demand for 5 of these. Forty-one kinds of laundry soap competed for attention in one place, the three most popular ones monopolizing 97% of the trade, leaving 38 brands distributed among only 7% of purchasers. This same survey showed that the market was being offered 1,675 kinds of toilet powder, 1,396 kinds of perfumes, 725 different toilet waters, and 600 beauty creams.

Manufacturers of farm machinery formerly made 240 varieties of drills and seeders; today they make less than 40. They used to make 209 varieties of the ordinary plow; now they make 30. Today 227 farm implements are doing the work for which a few years ago 2,135 were provided.

Loss and waste incident to needless diversification, while affecting producers and distributors directly, is also an indirect tax of real consequence upon the consumer. The total economic loss has doubtless equaled a billion dollars annually.

Industry is dependent, as never before, upon the working population for a market; and to increase consumption, purchasing power must likewise be increased. Successful efforts to lower selling prices, decrease costs, raise wages, and pay dividends have caused a mild revolution in industrial management. In these efforts simplification has proved its worth as a corrective and reconstructive measure, aiding in stabilizing industry on a new and sound basis.

Manufacturing Advantages of Simplification.—Diversification of product, or a variety of sizes and styles of a single line, results in small-scale production even though carried on in a comparatively large plant.

Production control and managerial supervision are more complex than in a small plant given over to one product, while machine set-ups and reset-ups with consequent delays and idle time are an added cost. Further, working arrangements obviously cannot be suited exactly to any one product. In other words, a plant that makes one product, and that product in a single size, model, or grade offers the ideal manufacturing situation from the standpoint of costs. And it is surprising how many such plants spring into existence, producing, among other things, ammunition, knives, one grade and kind of shoes, babies' underwear, men's athletic underwear, one kind of medicine in a single-sized bottle, one size and model of gas engine, face brick, paving brick, and cement.

The gains which accrue from simplification may be summarized as follows: [1]

GAINS TO MANUFACTURERS ARE:

1. Less Capital Tied up in
   - (a) Raw materials.
   - (b) Semi-finished stock.
   - (c) Finished stock.
   - (d) Jigs, dies, templates, and special machinery.
2. More Economical Manufacture through
   - (a) Larger units of production; reduced number of manufacturing units.
   - (b) Longer runs, less frequent changes of machine set-ups, etc.
   - (c) Higher rates of individual production.
   - (d) Accurate and proper estimating for production.
   - (e) More effective stock control.
   - (f) Better and more simplified inspection.
   - (g) Less idle equipment; reduced amount of equipment.
   - (h) Greater ease in securing raw materials, and conserving raw products.
   - (i) Less expensive handling of stock.
   - (j) Reduced clerical overhead per unit produced.
   - (k) Simplified and more accurate cost accounting.
   - (l) Elimination of waste in experimentation and design.
   - (m) Standardization of material inventories.
3. More Efficient Labor Due to
   - (a) Simplified training of employees.
   - (b) Better earnings, through increased individual production made possible by longer runs.
   - (c) Skill increased by repetitive process.
   - (d) Less labor idle from preventable causes.
   - (e) More regularized permanent employment.

[1] Cost and Production Handbook, Sec. 6, pp. 312–313.

4. Better Service to the Trade in
   (a) Better quality of product.
   (b) More prompt delivery.
   (c) Decreased quantity of sizes of packing required.
   (d) Less chance of errors in shipment.
   (e) Less obsolete material.
5. Simplified Selling.
6. Increased Rate of Turnover.
7. Easier Financing.
8. Fewer Factory Shut-Downs.
9. Compels Attention to Individuality in those features where it is desirable, by preventing attempts at individuality in those features where it is superficial and useless, and where standardization should prevail.

GAINS TO DISTRIBUTORS ARE:

1. Increased Rate of Turnover Due to
   (a) Elimination of slow-moving stock.
   (b) Staple line, easy to buy, quick to sell.
   (c) Simplified selling.
   (d) Greater concentration of sales on few items.
   (e) Standard patterns that are proven best sellers.
2. Decreased Capital Investment in
   (a) Stock on hand.
   (b) Repair parts on hand.
   (c) Storage space required.
3. Less Stock Depreciation and Obsolescence.
4. Decreased
   (a) Handling charges.
   (b) Clerical and accounting work.
   (c) Selling expense.

GAINS TO CONSUMERS ARE:

1. Better Quality of Product through ability of manufacturer to concentrate on better design and reduce manufacturing cost.
2. Better Service on
   (a) Complete products.
   (b) Repair parts.
   (c) Prompt deliveries.

Programs of Product Simplification.—The Division of Simplified Practice of the Department of Commerce was created to provide governmental assistance and cooperation to groups interested in simplification programs. It serves as a centralizing agency assisting manufacturers,

distributors, and users to cooperate in developing the best practice, and in making programs effective within the industry and with the public.

The nature and value of its work may be estimated from the following partial record of simplification programs which have been adopted:

	Reduction in Varieties From	To	Per Cent Reduction
1. Vitrified paving brick	66	6	91
2. Beds, springs, and mattresses	78	4	95
3. Metal lath	125	29	76
4. Asphalt (penetrations)	102	10	90
5. Hotel chinaware	700	279	60
6. One-pound folding boxes for coffee	100	2	98
7. Rough and smooth face brick	75	2	97
Common brick	44	1	98
8. Grinding wheels	715,200	254,400	64
9. Woven wire fencing	552	62	89
Woven wire fence packages	2,072	117	93
10. Milk bottles	49	4	92
11. Bed blankets (sizes)	78	12	85
12. Hollow building tile	36	20	44
13. Structural slates for plumbing and sanitary purposes	Average reduction		84
14. Roofing slates — descriptive terms, thicknesses and sizes	98	49	50
15. Blackboard slates — slab heights and sizes	251	52	79
16. Lumber (first revision)	Standard nomenclature grades and sizes for soft-wood lumber		
17. Forged tools	665	431	35
18. Paint and varnish brushes	480	143	70
19. Asbestos paper—sizes, widths, weights of rolls	72	25	63
Asbestos mill board—sizes, thicknesses	21	4	81
20. Bank checks, notes, drafts, etc.	Thousands	One size for each Instrument	

More than 300 consumer organizations have accepted simplified practice recommendations as agreed upon. Adherence to 11 such recommendations in one year ranged from 64% to 99%—an average of 85%—and shows that the American consumer is awake to the advantages accruing to him. Over 250 national organizations are cooperating with the Department of Commerce in furthering the movement.

Manufacturers may logically undertake investigation through the medium of a trade association secretary or other capable individual, who, authorized by the Secretary of Commerce, collects the necessary data and information needed for action.

Independent of national or trade programs, or as a part of the effort to make such programs effective, individual concerns may make progress

in several ways; i.e., (1) by reduction in styles, models, or sizes of articles made; (2) by standardization of parts; and (3) by intelligent limitation in adding new style or novelty items.

A bicycle manufacturer offering machines in three grades, with many choices in color and decoration, found it cheaper to make all in one design of the best quality. Color schemes were also reduced. Dealers at first objected, but they became enthusiastic when they were convinced that what really counts is the essential makeup and quality inside the product, rather than distinctions which have no reason except to be different. Quality is, in the end, a much better sales argument both for the manufacturer and for the dealer. Prospective customers then concentrate on the essential sales point of the article, its operating quality, and interior mechanical excellence.

With style goods, such as clocks, the number of designs may be limited. To continue the production of old automobile models would be ridiculous, yet the evolution in many other lines is as rapid. The best sellers usually are included within a narrow range of a company's line. When up-to-date designs are added in response to sales department pleas, out-of-date ones may logically be discontinued. This practice avoids cluttering catalogues with obsolete items, the stocking of disused patterns, the unnecessary maintenance of stores and finished stocks with consequent cumulative investment costs, and added production, managerial, and sales expense. Even style goods may be simplified by uniformity with regard to fabrics, qualities, and the unseen parts. Diversity is secured in upholstered furniture by simply varying the selection of upholstering material used.

Diversification.—Although there are many manufacturing and distributive economies to be gained from simplification, there are times when it is more profitable for a company to follow the opposite policy and diversify. Diversification consists in adding new products and in providing for variations in commodities to meet customer demands. It is mostly a sales rather than manufacturing problem, but it is sometimes connected with research. When the sales for a company's product fall off, as in an economic depression, idle equipment may be put to use producing new types of goods for which sales can be found. When economic conditions again allow it, the policy of simplification will be resumed. Over a long period simplification has been found to be the most profitable policy to pursue, but there are times when a manufacturer is driven from that position on account of necessity. Some very large companies are powerful enough to diversify by establishing new plants to take advantage of the work of their research departments.

Cellophane, Nylon, and Neoprene are examples of this in the Du Pont organization. Each new product is at the same time highly simplified in its own manufacturing establishment.

Aims of Diversification.—Companies which see fit to diversify their lines probably have in mind one or several of the following objectives: [2]

1. To use excess plant capacity.
2. To employ present equipment more fully.
3. To eliminate seasonal humps.
4. To guard against dependence on one industry.
5. To keep distributors busy the year round.
6. To get in on the ground floor of a new industry.
7. To supplement a product which has a permanently declining or circumscribed market.
8. To make and sell a product first designed for a company's own use.
9. To increase consumption of a basic material in new forms.
10. To make new products requiring much the same manufacturing processes as the old products.
11. To secure larger share of business in same general market.
12. To increase sales of an old product by entering new price field.
13. To widen consumer channels for the same product.
14. To utilize by-products.
15. To stabilize a business by avoiding dependence on any one of half a dozen products.
16. To secure increased volume, thus cutting overhead and increasing earnings.

Types of Diversification.—Diversification embraces four general types as follows: [3]

1. Where new products unrelated to old products are added.
2. Where new products related to old products are added.
3. Where old products are introduced into a new price field.
4. Where the market for an old product is broadened to protect the manufacturer against reliance on customers in one industry.

A company making oil burners added electric refrigerators, thereby keeping its sales agencies and plant uniformly busy. Sales were made to the same consumer group, and the same plant facilities, equipment, and skilled workers were utilized effectively in making the new product. Another manufacturer in the farm equipment field added trucks which

[2] "The Profits of Diversification," a special report to executives issued by *Business Week*.
[3] *Ibid.*

it sold to both farm buyers and industrial users; thus creating a broader, more stable market. The Caterpillar Tractor Company found an industrial market for its Diesel power units.

The success of the Packard Motor Company in extending its line of cars into the lower price ranges enabled it to strengthen its market position, increasing sales and decreasing overhead.

The Koppers Company, Pittsburgh, has carried its diversification efforts through an unusual range. The company started with the building of coke ovens which produce five basic products—coke, gas, tar, benzol products, and chemicals. "Today the company designs, builds, produces, manufactures, distributes, and operates in many fields. Such diversification protects the company from the dangerous limitations which one market presents. It provides essential commodities whose particular markets are never wholly inactive. It provides the fullest employment of engineering and technical knowledge. . . . Major buyers from one Koppers producing unit have need for at least another, and often many of the products of other divisions." [4]

In a depression period industrialists not only seek new products, but endeavor to stimulate demand by style changes and catering to individual preferences. Automobiles and kitchen stoves illustrate this latter trend. Fortunately, the advance in manufacturing techniques has enabled producers to offer more attractive products in greater variety at less cost, making this idea feasible.

Simplification and Standardization.—Simplification is the logic of mass production; standardization is the basis for putting this logic into practice. Without the application of standards throughout the industrial organization simplification is impossible, and the desire to simplify remains merely a good intention. First, standards are the source of knowledge concerning procedure. Without an analysis of a process it is impossible to set up a standard, thus, setting up standards provides an impetus for better organization. This applies not only to the manufacturing line but also to costs, records, purchases, and every other department of the plant. Once the standards are set up they are easily accessible, and may be changed whenever the dictates of good management demand it. The effort to simplify involves setting up standards, which are ". . . simply a carefully thought out method of performing a function, or a carefully drawn specification covering an implement or some article, of stores, or of a product. . . . The standard method of doing anything

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[4] "How Product Diversification Stabilizes Business," by C. J. Ramsburg, *Executives Service Bulletin,* Vol. 16, No. 9, Policyholders Service Bureau, Metropolitan Life Insurance Company.

is simply the best method that can be devised at the time the standard is drawn."[5]

Hence standardization necessitates the establishment of some definite model, procedure, or specification to which future products or practices will conform. Simplification, being the elimination of useless or uneconomical variety, supplements standardization by making the idea effective over a period of time when diversification is prone to occur. Thus, it makes work easier for all concerned.

Simplification leads directly to specialization, and specialization of effort necessitates conformance to a predetermined plan. Without fixed procedures, policies, and minute conformance to established detail, executives would lack any basis for effective management, unification of control, and uniformity of outputs that now exist in modern industry. Procedures could not be formulated, scheduling would be ineffective, and costs would be uncertain and greater.

The general application of standards in industry is necessary in order to transfer the skill of the expert to the inexpert. It greatly increases the productivity of the average worker. With increased individual outputs workers may enjoy more of life's opportunities, and the demands of an advancing civilization may be better satisfied.

The Origins of Standards Committees.—Standardization work started with individual firms, spread to industries, and is now securing organized national and international attention. The American Engineering Standards Committee, known as the A. E. S. C., was organized in 1917 to "formulate methods of cooperation between the various groups interested, to prevent duplication in standardization work and conflicting standards." Affiliated with the A. E. S. C. are more than 150 trade associations, and through this channel the individual firm is linked with trade and national practice.

The development of standards started as a more or less incidental part of the manufacturing department's activities. More recently its recognized and increasing importance has resulted in the creation of a separate division or department within the plant, with responsibility only to the head of the engineering department or works manager. Those engaged in the work must possess the requisite authority to overcome mental inertia and obsolete practice wherever found. The staff personnel should be qualified by technical training and operating experience, and should know the demands which will be made upon the products in use.

[5] "Academic and Industrial Efficiency," by Morris L. Cooke, *Bulletin of the Carnegie Foundation for the Advancement of Teaching*, No. 5, p. 6.

Policy may suggest creating a standards committee composed of representatives from the major departments, such as sales, manufacturing, purchasing, and engineering along with the head of the standards department. Its function would be to pass on the standards proposed, and to exercise influence in furthering the standards idea throughout the organization by educational work, a step made necessary by the inevitable opposition which arises when changes are proposed.

An Example of a Standards Committee.[6]—The National Cash Register Company developed the following plan for analyzing and checking proposed improvements in its product. A committee in the engineering division passes on all contemplated changes in the established line of machines and every proposed addition to it. Another general committee examines the changes after they have been incorporated in complete machine units or models. This latter committee is composed of five sub-committees, as follows:

1. The functional committee, made up of representatives from the sales department, passes on each new or changed mechanism to ascertain if it meets the requirements of that particular department.
2. The manufacturing committee considers the mechanism principally from a tooling and production standpoint. The work of this group results in changes in design, which often means the saving of hundreds of dollars in tools, in processing, and in producing the finished product.
3. The assembly committee considers the mechanism from a functional viewpoint and studies means for limiting assembly costs.
4. The inspection and research committee analyzes the mechanism from a functional, operating, and durability standpoint.
5. The sales-service committee, consisting of trained service men, studies the mechanism from a customer and service point of view.

Representatives from the engineering committee attend all sub-committee meetings. The research and engineering divisions formulate specifications for materials to use in the various parts.

Standards Applied to Management.—Standards pertaining to the general management of the business include those dealing with finances, costs, procedures, and records. Financial standards frequently take the

[6] "Prevention of Waste and Reclamation of Materials," by J. Q. Salisbury, *Mechanical Engineering*, Vol. 57, No. 9, p. 563.

form of ratios, and show the relationships which exist between various aspects of the business. The ratio of current assets to current liabilities is always important. The chief executive will also wish to be informed with regard to cash on hand, quick receivables, net income, funded debt, the relation existing between sales and inventories, and the like. Other financial relationships are given in Table 17, page 468. The data in Tables 17 and 18 are also effective in cost control. Cost comparisons are desirable in connection with advertising, sales, general management, materials, labor, factory overhead, and other expenses.

Standards of procedure are prepared to cover those activities which are participated in by more than one department, and indicate just what each is to do, when, and how. They serve as a guide to and a check upon performance which unifies the activity as a whole. Purchasing routines, material control procedure, and the handling of orders would be examples. Performance standards should be determined for this work. Similar standards may be established for individual tasks within the departments and divisions.

Standards Applied to Manufacturing.—The simplification of a line of products results in a concentration upon specific items, which become the standard products of the company concerned. In this connection the term implies uniformity in a limited variety of sales items produced in relatively large volumes, items carefully selected and designed to offer maximum serviceability and usefulness.

Early in American industry efforts to specialize labor suggested the desirability of producing element parts after a master piece or standard, and each of them precisely like all others of its kind. This permitted interchangeability, facilitated production, and offered many advantages to the user. As the relative importance of design, quality, finish, and selection of materials increases, more careful determinations of the accepted standards in these particulars follow. In every industrial plant opportunity for application of standards is almost infinite. A program may well include some or all of the following phases:

1. Nomenclature
2. Materials
3. Processes
4. Equipment
5. Tools
6. Designs
7. Element parts
8. Sub-assembly units
9. Standard methods and practice

Nomenclature.—Confusion is occasioned by indefiniteness of descriptions and contradictory terms used in naming objects. The language of industry should be standard and universally known and used.

Materials.—The standardization of materials usually follows a technical investigation of the company's products in use, and of the various materials as to kinds, sizes, and grades purchased. Usually changes will be found possible which will permit reduction in varieties stocked, and at the same time improve the product or lessen its cost. Buying specifications for the guidance of the purchasing department may then be prepared to afford effective control.

Standard materials are of advantage to the manufacturing department for the following reasons. Greater uniformity in purchased materials under carefully drawn specifications makes possible greater refinement in technical designing and better utilization of the material. Workmen will thereby achieve more uniform and better results in both manual and machine operations. Waste and spoilage will decrease, the effectiveness of machines be increased, and the average quality of the output raised. Necessary production times will show less variation, a most important factor because of its effect on employee earnings and plant morale.

The ultimate user of the commodity will get uniformity in his purchases, and find that advertisements and selling appeals prove dependable. Because of this the dealer will find sales easier, fewer adjustments to make with disgruntled customers, and collections more prompt. This favorable situation will be reflected to the manufacturer in easier collections, and increased sales will be obtained at less cost.

The General Motors Corporation lists over 19,000 specifications of materials and supply items. That these are not needlessly arbitrary is suggested by the following excerpt from a specification of factory gloves:

> The gloves purchased on this specification need not meet the specification in every little detail, but in a general way must conform to the description. The specification was not written with the purpose in mind of having manufacturers fabricate small lots of gloves peculiar to this specification. A standardized commercial glove now in production is desired and all gloves will be purchased from samples submitted. Extra consideration will be given to manufacturers whose gloves most nearly approximate the important points in construction.

Processes.—The choice of processes is influenced by the investment necessary to install equipment. A new process, though economically desirable from an operation standpoint, may not be justifiable considering capital cost involved in scrapping old equipment and acquiring new. Other considerations are the likelihood of obsolescence of the new process, and the anticipated volume of future orders.

Equipment.—Machinery and equipment offered to the manufacturer are of two kinds: (1) general purpose machines, and (2) special purpose machines. The former are produced on a quantity basis, usually by several competing firms, and are suitable for a comparatively wide range

(Courtesy of Automobile Manufacturers Assn.)

Figure 92. These Giant Machines, Built Expressly for Drilling Engine Blocks of a Single Design, Are Essential to Speed and Accuracy of Production

of similar work. Special purpose machinery is equipment limited to a narrow field of usefulness, as for a single operation. For example, machinery for shoe plants, because of its extensive use, may be produced on a standardized basis. The same is true of much machine-shop equipment, and various kinds of textile machinery.

Special purpose machines are economical in operation. If they are made and sold in sufficient numbers to justify quantity production, their cost is comparable with general purpose equipment similarly produced. A high degree of specialization in manufacture favors the use of single purpose equipment. Special machines which are produced singly or a few at a time according to individual specifications cost much more to build, and repair cost is greater. Objections to the utilization of such equipment are the possibility of faulty operation, and lack of clearly defined or real needs. Yet real needs of this kind adequately cared for by special equipment yield a distinct saving, and may give the fortunate firm a distinct monopoly advantage. Figure 92 shows a special purpose machine used in the mass production of automobiles.

A jobbing or customer-order business suggests fewer repetitive operations, but greater variety. In these shops, general purpose machines adaptable to a range of similar operations naturally prove economical in investment cost to a degree not usually offset by the cost of changing set-ups and less economical performance. When it is possible to keep special machines busy continually they should be added.

Repair, maintenance, and idle-time costs are favorable to the general purpose machine, as well as the hazard of investment loss due to changing production demands. Resale values are also higher.

In order to standardize his shop a factory manager may make minor changes and machine adjustments which will bring them into line with others from the operating standpoint. For example, a superintendent of manufacturing states:

> If the machines of any one class have different feeds and speeds, it becomes necessary to route work to a particular machine. This may result in a congestion of work at one or two machines while others are standing idle. If the latter are utilized they will necessarily have to work at a lower rate of output than the job analysis calls for, with a consequent failure to meet the schedule. On the other hand, when all machines of a class are of the same capacity, the work may be routed to the group, and put in the first one of the group that finishes the job it is working on. This immeasurably simplifies the routing, and makes the dispatching of work in the shop much more rapid.

Tools.—Not only must actual cutting or operating tools be considered, but such accessories as jigs, fixtures, wrenches, blocks, bolts, etc. It is now often customary to provide the workman with a set of the tools which he needs in connection with a particular operation, and to indicate by means of an instruction card the purpose and sequence of their use. This information is supplied by job standardization work in

connection with time and motion studies. The difference between this method and giving the workman a job to do and letting him choose his own tools and accessories from a general supply may be several hundred per cent in output. High machine-hour charges and high man-hour rates influence the achieving of minimum times in machine set-ups, which may amount to an appreciable percentage of actual operation time. The right size blocks, bolts with proper washers and length of threads, wrenches adjusted to fit, all in proper quantity and condition, make "clock-work" preparation a matter of established routine as to motions and time.

Metal cutting tools vary greatly in effectiveness depending upon quality of steel, shape of cutting edge, coolant used, tempering, and condition of the tool at time of use. The workman cannot possess the requisite technical knowledge to make proper tool selections, and may have erroneous, prejudiced ideas which are expensive to the management. His ideas of effective shapes, speeds, and feeds are necessarily superficial. Management must evolve tool standards by engineering research and investigation. Simplification plays an important part of tool standardization work, thus reducing inventories and investment cost. Five kinds of pliers were found to suffice in one shop where forty kinds were kept in stock.

Designs.—Standardization of product design involves a study of the style factor as analyzed in discussing simplification. In machinery lines a balance is to be maintained between mechanical characteristics that are desired, cost of production, and sales demand. Questions to be considered are sizes, degree of refinement in shop practice, allowable working stresses, factors of safety, and general appearance and finish.

Element Parts.—E. A. Johnson and O. B. Zimmerman, writing in *Agricultural Engineering*, say:

There exists in every machine produced, certain simple elements which repeat themselves in function in other machines, and which may have either shape or size which will be peculiar to that industry. We have, for example, gears, axles, keys, chain, belts, etc. By a systematic study of the requirements of each of these elements, and the establishment of a minimum number of graded sizes, making them uniform throughout the company's production, we may establish much in the way of standardization. . . . In the majority of cases thorough analysis will permit the establishment of basic design features, relations and proportions which can be adopted as company standards.[7]

[7] "Inter-Company Standardization and Its Relation to General Standardization," by E. A. Johnson and O. B. Zimmerman, *Agricultural Engineering*, Vol. 4, No. 12, p. 187.

The tendency toward unnecessary variation is appreciated by considering examples of the elements encountered and the differences in type and design possible.

TABLE 9. EXAMPLES OF ELEMENTS [8]

Bearings	Plain, bushed, roller, ball, thrust, removable
Bolts	Machine, carriage, plow, special
Chains	Malleable, steel, link, roller, silent
Gears	Spur, bevel, spiral, worm, skew
Hubs	Malleable, steel, cast, tube
Keys	Square, gib, feather, taper, Woodrull
Levers	Hand, foot, lifting
Nuts	Special, lock, plain
Pulleys	Plain, crowned, flanged, grooved, lagged
Screw threads	Coarse thread, fine thread, square, special
Spokes	Round, oval, flat
Springs	Tension, compression, torsion, special
Washers	Lock, plain
Wrenches	Socket, open, monkey

What has been accomplished with respect to one element—coiled wire springs of the round-wire, tension, and compression types—illustrates what can be done with hundreds of others.[9] This standardization takes effect on more than 3,500 tons of springs used yearly.

1. Establishment of definitions of terms peculiar to that product.
2. Specification of material used to cover steel wire.
3. Reduction of wire gauges used from 6 to 1.
4. Reduction in wire sizes from 51 to 31.
5. Concentration of spring manufacture in one works.
6. Establishment and unification of heat treatments.
7. Reduction in design methods from 7 to 1.
8. Development of design tables, covering strength, load and coil diameters, with safe ratios to use for avoiding material waste.
9. Establishment of standard spring ends, thus reducing breakage.
10. Establishment of fatigue values to accord with spring operation.
11. Establishment of standard drawings of springs at all works.
12. Reduction in number of springs from over 800 is under way, and the establishment of a series of preferred numbers has begun.

Standardization effort through simplification and perfection of elements tends to better quality and increase serviceability, by "placing in

[8] *Ibid.*
[9] *Ibid.*

the user's possession materials, designs, elements, units and complete machines which will be examples of first-class engineering, when viewed from the several economic standpoints surrounding that product." [10] Variations in details of construction, use of materials, and designs usually denote a lack of foresight and intelligence, rather than the contrary. In the great majority of cases likeness of parts is distinctly desirable, from the point of view of manufacturing economies, distribution problems, and convenience in use, as facilitating interchange of parts with other machines and obtaining repairs and replacements. Differences from standards should be permissible only when some gain is effected. Through trade associations and the A. E. S. C. the standards may be those common to the industry or those accepted universally may be adopted for the company. Users will more and more find it possible to interchange elements among different sizes, makes, and kinds of equipment.

Sub-assembly Units.—Some products cannot be finished completely for stock because of slight differences called for by customer orders. Many items in upholstered furniture are completed except for finish upholstery. Elevator manufacture involves slight differences in mechanical and electric equipment to suit varying specifications. Machine manufacturers offer options in choice of designs. To expedite deliveries and enable the factory to keep going in dull times these units may be standardized to a very great extent. For assembly units such as transmissions, carburetors, wheels, lamps, starting equipment, safety devices, automatic signal systems, the same design may be used for different installations and uses. For example, an electric signal system for elevator control may be essentially the same in each case, though the elevator designs differ. Unit assemblies may also be made of control mechanism, structural parts, safety equipment, and motors. Companies manufacturing trucks and tractors of several capacities find some assembly units interchangeable, as the same engine unit for car and truck.

Standards of Accuracy.[11]—Interchangeable parts need to be made to accurate dimensions if they are to fit together and work effectively when assembled. The steadiest surgical hand is able to work within the accuracy of one fiftieth of an inch. In eye surgery this measure of accuracy has been increased by the use of an instrument to one 250th of an inch. In the making of a Ford car there are thousands of measurements of this accuracy: 700 measurements accurate to within one 1,000th of an inch; more than 200 measurements accurate to within five 10,000ths

[10] *Ibid.*
[11] From a pamphlet "Final Assembly," by W. J. Cameron, of the Ford Motor Company.

of an inch; and fourteen measurements accurate to within one 10,000th of an inch. To achieve this accuracy precision gauges are used measuring to the 10,000th of an inch, which in turn are checked by Johansson master gauges measuring to the 1,000,000th of an inch to keep them precise.

This science of precision is extended similarly to all types and kinds of manufacture. It contributes to low production costs, less waste, quiet operation of machine products, and longer wear in use.

Standards Applied to Jobs.—The standard way evolved for performance should be the best way under prevailing conditions. Men trained uniformly in standard practice are, therefore, most effective; and the existence of standards makes easier the adequate training of new employees and their transfer from place to place. They provide a means for the transfer of skill from the expert to the inexpert. With an accepted method of performance in effect, comparisons may be made and accomplishment in economy and efficiency measured and encouraged. Day by day savings may be small and yet over a long period they may amount to enough to justify detail study which would not be warranted when the methods of performance vary from time to time. Instruction cards, as illustrated by Figure 123, page 414, provide records of standard methods evolved.

Corporations operating in different localities, and employing thousands of workmen, even in different countries, benefit greatly by the wide application of standard practice in its effect on cost, executive control, and grade of accomplishment. Thus, time studies taken in Chicago are used effectively in over a score of branch plants in America and abroad. Telephone companies know that water has the same characteristics wherever found; lightning is destructive everywhere; a cable-splicing job should be handled the same way in every case; and No. 8 wire will carry the same amount of current in every locality. Standards in these matters provide a medium for effective control, simplify administration, and eliminate waste due to erroneous and varying ideas of what is best. They serve as a vehicle for the executive will, assure the best results obtainable, and permit the centralization of responsibility and authority in a way not otherwise possible. A telephone company found that the number of troubles causing service impairments in a group of line and cut-off relays where relay adjustments had been made on the basis of the current flow method, were but one-third of those in a similar group of relays adjusted by another method.

Standard Practice Instructions.—Organization manuals outline responsibilities and duties of departments, divisions, sections, and individ-

uals. In well-established organizations executives find it desirable to have management practice and procedure formulated and embodied in standard practice instructions. In these ways the work of subordinate executives and individuals is clearly outlined, responsibility and authority clearly depicted, the scope of duties indicated, and the manner of performance outlined. Standard practice instructions may also be issued from time to time in bulletin or letter form, applying to personnel, product, policies, or methods and procedures.

In larger organizations standard practice manuals supplement organization charts and manuals. In smaller ones standard practice instructions may picture the structure of the organization and outline the responsibilities of individuals. They aid management in establishing a known and dependable managerial practice and effective control. As they are most often kept in loose-leaf form, revisions and additions are readily made. Mimeograph copies may be issued or they may be printed. Standard practice instructions provide a welcome reference source when new or unfamiliar tasks are to be performed.

The advantages of this formal method of administration are several. (1) It implies deliberation and forethought in planning; (2) instructions so issued are less subject to debate or question, and hence may be complied with more readily and completely; (3) misunderstandings, and especially alibis for this alleged reason are fewer; (4) responsibility is fixed; (5) an effective medium is provided for effecting changes and betterments as need arises; (6) lines of authority are clear cut and definite; (7) the organization as a whole is kept apprised of changes and progress; (8) less supervision is required and the time needed to give verbal instructions is saved.

When the method is not a success, the reasons for failure may usually be ascribed to fairly definite causes. Poor organization and faulty or hasty procedure may necessitate issuing too many and conflicting instructions, or the instructions given may have proved unreliable and ineffective in operation, or their authority may be questionable. They should be prepared and issued by some centralized agency such as the comptroller's department, and signed by him and the general manager or a vice president.

Figure 93 shows an example of standard practice instructions pertaining to responsibilities of a factory manager.

There is nothing more stifling to initiative and individual effort than uncertainty as to the responsibility or authority which a position carries with it. Efforts to do constructive work should not generate unhealthy rivalries or friction among co-workers, which an absence of clearly

FORSYTH FURNITURE CO.
Charlotte, N. C.
STANDARD PRACTICE INSTRUCTIONS

No.............G 5
PAGE..............1
EFFECTIVE....

SUBJECT: RESPONSIBILITIES OF FACTORY MANAGER

FACTORY MANAGER
Responsible to the General Manager for

1. Direction, supervision and co-ordination of all departments of the Manufacturing Division of the business, as shown on Organization chart.
2. The determination and administration of all policies governing the Manufacturing Division.
3. The proper and economical execution of all manufacturing programs and shipping orders.
4. The proper care, and maintenance of, and accounting for, all of the Company's property which is assigned to the Manufacturing Division.
5. Issuing purchase requisitions on Purchasing Department for all materials, supplies, machinery, equipment, etc., required for the execution of manufacturing programs and shipping orders, and for upkeep of the property assigned to the Manufacturing Division.
6. Planning the methods of manufacture, the introduction of all special tools, machines, and methods which will improve the quality of the product or reduce the cost of production in a profitable way.
7. Issuing all Production Orders to cover work in the manufacturing departments, on all Manufacturing Programs and Shipping Orders.
8. Planning and scheduling of work on Production Orders; the care and upkeep of the storeroom; the upkeep of stores records; also for records showing progress of the work on all Production Orders and readjusting schedules to conform to actual progress.
9. Issuing of all Plant Orders covering necessary alterations to maintenance of all property which is assigned to the Manufacturing Division.
10. All matters relating to Finished Stock and Traffic, including receiving, shipping, supervision and upkeep of trucks and teams, also for all clerical work connected with the records and follow-up of this work.
11. The employment of all help and the determination of the wage schedules governing them.
12. Installing and maintaining all safety devices and for supervising medical attention and inspection of plant for all divisions of the company.
13. Operation of the power plant, elevators, motors, and of all transmission machinery throughout the plant, and for their repair and upkeep, also for the supervision of all millwrighting, machine repairs, and electrical work.
14. All repairs to buildings and their equipment, also for furnishing proper light, heat, water, ventilation, sewerage, and fire protection for the buildings.
15. The inspection of all incoming materials, work in process of manufacture, and the finished product.

Wm. R. Jones
General Manager

Figure 93. Responsibilities of the Factory Manager

defined boundaries of activity is sure to do. The danger is that the force of dynamic constructive personalities will be lost to a concern because of inability to function freely. Adherence to established routine and practice on the part of all concerned is essential to smooth operation, and the lack of it is especially confusing in large organizations where personal contacts and understandings are not possible. Standard instructions take cognizance of all that influences the matter in question, and should represent the decision of a master mind concerning it. If, when issued, they are often subjected to valid criticism, and amended, or are in conflict with instructions from other sources, their force and effect are diminished.

STANDARD PRACTICE INSTRUCTION

SUBJECT		
NON-PRODUCTIVE ORDERS	CLASSIFICATION	80.0001
	SHEET NO.	1
	DATE	3-27-
	SUPERSEDES	
	WRITTEN BY	Council
	APPROVED BY	Committee
Factory General DEPARTMENT		

0.1 PURPOSE

0.11 The purpose of the Non-Productive Work Order is to authorize (after proper approval) a department to do a particular and specific non-productive job.

0.2 FORM

0.21 This order is known as "Non-Productive Work Order" (commonly called N-Order), Form 2B, and consists of 5 copies, consecutively numbered. These consecutive numbers will be the order numbers and are prefixed by "N". The last, or #5 copy, is of manilla paper. The copies are titled and collated in the following order:

#1 Copy - Cost Department
#2 Copy - Issuing Department
#3 Copy - Budget Department
#4 Copy - Work Copy (follow-up)
#5 Copy - Work Copy

0.22 This form was revised and became effective July 5, 1938. Registers containing these forms are located in six departments: Machine Shop, Composing, Press Room, Collating, Superintendent's Office and Maintenance.

0.3 USE OF COPIES

0.31 #1 - Cost Department Copy - Must be sent to the Cost Department and will be used by them to ascertain cost when job is completed. All job tickets and requisitions pertaining to "N" orders will be accumulated by them and filed by order number.

0.32 #2 - Issuing Dept. Copy - To be retained by the department issuing the order and will be used by them as a follow-up copy.

0.33 #3 - Budget Copy - Must be sent to the Factory Budget office and is used by this department for control purposes.

0.34 #4 - Work Copy (white) - Must go with the manilla copy to the department executing the order and will be used by that department head as a follow-up on the workman doing the work.

THE STANDARD REGISTER CO.

FORM NO. 5 19

Figure 94. Standard Practice Instructions Pertaining to Non-Productive Orders

(From "My Foremen Help Me Manage," by F. W. Stein, *Factory Management and Maintenance*, Vol. 98, No. 4, p. 42.)

Difficulties arise in securing compliance with orders which are thus subject to question. Figure 94 furnishes an illustration of standard practice instructions designating the approved procedure for the issuance of non-productive work orders.

Standard practice instructions as used to facilitate and control management procedure are different from the instruction cards issued to workers in connection with production operations. The latter list the sub-operations or elements in sequence which make up the job, list the equipment and tools used, and show the standard time for elements and the total job time. See Figure 123, page 414.

Society and Standardization.—Objections have been made that the constantly increasing tendency toward standardization in industry tends to make morons of industrial workers, hinders progress, makes the world a monotonous place in which to live, and takes away competitive advantages of individual firms.

The most important complaint is with regard to its effect upon the worker. Unquestionably, specialization of labor is increased. Many workers perform but a single operation on a part, and in extreme instances this is limited to but a few motions. Skill continues to be transferred to machines to an increasing extent. As a consequence are industrial workers degraded? Are initiative and inventive talents being stifled? Will the conditions contribute toward a wider gap between employer and employee socially and in manner of living?

With increasing standardization has come greater perfection of machinery. More and more the drudgery of the world is being performed by machinery. Workers previously capable of only common labor have been elevated into the ranks of the semi-skilled, as machine operators. An increasing number of highly skilled men are constantly required to make, repair, and in many cases to operate machine equipment. The operators of most machines are required to be workmen of ability, proficiency, alertness, and skill. The making of tools, dies, patterns, and the like calls for great skill and ingenuity. Many machines are costly and intricate, requiring great skill to operate. Virtues once of lesser importance in workplaces were responsibility and character; now they are often indispensable. Capable men frequently rise to a place in the ranks of management as supervisors, time study men, or in planning work. Industry finds it necessary to offer special inducements and provide facilities for the training of skilled mechanics and technicians to meet its needs.

A veil of romance has been thrown about the old-time craftsmen who labored twelve and sixteen hours a day. Some were truly great artisans,

but the lot of labor was not always a happy one in the days of the handicraft shop; the majority of workers were limited to tasks affording little opportunity for creative workmanship. Primitive labor is always hard labor, shortening life, dulling intellects. He who wields a shovel all day in the sun, mines coal, handles pig iron, or works logs into lumber, welcomes the help of machines, and finds new compensations of greater value than those lost. Master workmen in industry today achieve greater perfection and beauty of product with no less exercise of brain and skill than the old time craftsman. The industrial worker today who complains of lack of opportunity to exercise skill and initiative, usually lacks these qualities, for specialization makes for expertness and the thorough understanding of tasks which leads to improvements.

Critics forget the 8-hour day with a 40-hour work week which so many enjoy, the higher standards of living which prevail, the increased opportunities for education and recreation, all are a consequence in large measure of the standardization they decry. They forget also the differences in mental capacities, abilities, and aspirations of men, as well as the fact that many occupations are little influenced by standardization work.

As previously pointed out, standards do operate to prevent change unless of proved advantage. Railroads, originally of various gauges, were at a decided disadvantage in making other than local shipments. Standardization immeasurably facilitated commerce. Probably today a wider gauge would be more economical, but the tremendous investment in tracks, cars, bridges, tunnels, and locomotives hinders the change. Fabric automobile tire standards did not prevent the adoption of cord tires, nor the later acceptance of the low pressure type. Constantly increasing standardization practice among automobile builders is improving cars and reducing their price. The early acceptance of standard shapes and weights of steel sections has not hindered progress in the building industry. Standardization is the life of the electrical industry, although progress is constant.

Standardization does not necessarily mean monotony. People are of a standard type, yet though they are essentially alike, each person is different. Hats, clothing, furniture, and automobiles are no less interesting because of the application of standards. Much standardization work, indeed, has no effect upon appearance.

That standards take from firms competitive advantages has some basis for argument. Unlike machines must be supplied with repair parts. Monopoly advantage or distinctive service brings orders. However, no one will contend that the adoption of a standard lamp base in lieu of the 180 different bases has not greatly increased the use of electric lamps.

Each railway moves much more freight over standard gauge tracks than it would otherwise. When differences are immaterial no profit is derived from them; when they hinder freedom of use maximum service is not rendered; when they are not justified, the fact will be reflected in sales. Experience shows that use is facilitated by standardization, products are uniformly better, costs are reduced and the market broadened, to the greater advantage of producers. Batteries have standard terminals, filing cases standard compartments, tires are standard in essentials of design and sizes, lamps, standard intensities of candlepower, all to the advantage of user and maker alike. On the whole, the values which standardization offers to society greatly overbalance the losses it occasions. Furthermore, such losses as do result can be replaced by gains intrinsic to the present industrial order. These would be impossible without the products of contemporary industry.

CHAPTER 18

HUMAN RELATIONS

THE PROBLEM OF HUMAN RELATIONS

The Individual in Society.—The history of mankind is a record of strife. Differences of opinion and mutually exclusive purposes are as characteristic of contemporary times as of centuries past. But this aspect of man's history is more fundamental than superficial observation of the fact might show. In many of these recorded struggles there is clearly evident the ordinary motivations of men—desire for material gain, pride, ambition, desire for power, racial prejudice, or religion. It is equally clear from a reading of history that these same motivations do not always result in open struggle. So long as man is a finite individual, he is limited in his choice of purposes and ideals, and individual differences will result in different motivations and intentions. No two men pursue the same goal, and their goals may well be, depending upon the circumstances, mutually exclusive. This may be the source of open struggle; it has often been such in the past. Two individuals motivated by ambition may desire to hold the same office or position. If they compete openly one of them may lose, the result may be a party split, lack of cooperation within an organization, or, in the case of nations, war. On the other hand, such competition may result in the division of power, and consequent cooperation for other mutual ends.

Some assume the differences which arise between employees and employers are occasioned by injustice in connection with the employment situation. This is not necessarily the case. The relation of labor to management is not an abstract relation of class to class, but a relation of particular individuals doing different kinds of work, and with more or less different ends in view. Placing the emphasis upon the divergence of human interests does not mitigate the conflict, but viewed from this perspective the conflict does offer itself to solution. Divergence of interests can be resolved given sufficient knowledge of the facts and ingenuity. Just as competition between two firms may result in better service to the public and a higher quality of merchandise, the resolution of conflicting interests may result in social progress.

Human Relations in Business.—It is a mistake to assume that in modern industry the interests of employer and employee are mutually

exclusive. From a fundamental viewpoint the economics of modern industry show that what is good for the industry is likewise good for the employees. Thus, a higher standard of living for workers results in a more progressive and more profitable industry. This is the basis for the resolution of the human conflicts between employer and employee. In Greece production was carried on by a slave for his master. This master and slave relationship gave way during the Middle Ages to serfdom, and this in sequence to the master and servant concept, and employer-employee relationship with rights of contract. Mutuality of interests in these relationships was seldom recognized. Advantage gained by one party was presumed to be at the expense of the other. This is not the case today, and the recognition of this mutuality of interest is coming to be more and more a means of resolving conflicts.

It is primarily in the recognition of the fact that human conflicts in industry must be resolved from the point of view of social well-being that distinguishes present industrial relations from those of the past. The recognition of the general social background of both capital and labor forms a common basis for the discussion of conflicts arising from human differences. These conflicts are real, but the necessity and basis for resolving them are implicit in the need for a social organization. The furtherance of the general social level reacts to the benefit of both the employer and employee, and any conflict between the two should be resolved with this in view.

The ultimate mutuality of interest between employee and employer is today widely recognized by industry. For example, an organization with 350,000 employees seeks to eliminate entirely from the minds of its workers the master and servant conception. The endeavor is to emphasize the broader social context, "To make each one feel that he is a part of the business and, therefore, ready to assume all the responsibility, both individual and joint, as well as to enjoy the privileges and compensations that go with that relationship." [1] And, "We want to make everybody feel like he is a part of the outfit, because we believe that that is the only way that a man puts his best life into industry, which is good for industry, good for himself, good for all his associates, and good for society." [2]

The Problem of Human Frailty.—In addition to the broader problems of human interests which have been discussed, it is essential to remember that a great deal of human relations work in industry arises

[1] Proceedings of the Bell System Educational Conference, p. 245.
[2] *Ibid.*, p. 242.

from the individual characteristics of the employees. If all the people in industry were industrious, temperate, well-behaved, and capable, a good deal of friction would be eliminated. The problem of influencing and aiding people in this direction, however, has not been successfully solved. It has been estimated that six-tenths of human distress is due to intemperance, habitual idleness, or vice; three-tenths to old age and weakness following an improvident youth, and only one-tenth to sickness, accident, or loss of work.[3] In part the situation is also a consequence of heredity, of inborn incapability or weakness. Human frailty is largely outside the realm of the economist and the administrator, yet they must reckon with it, and it is a problem of governments. Most of the deficiencies in human beings cannot be corrected or eliminated by any plans which management may make, nor has any government or human agency ever achieved the desired objective in this direction.

It is well to appreciate that as long as human frailties persist, trials and tribulations are inevitable, and that they are not a consequence of any particular form of social, economic or political organization. Leaders can understand, sympathize, and to an extent alleviate the effects of the causes mentioned, but many aspects of the problem cannot be reached. Efforts to improve mankind involve the use of moral and spiritual forces, education, and the physical improvement of the race, steps which can be but slowly taken over the centuries. In these ways only, however, may the perennial suffering of great masses of men be greatly relieved.

What Employers and Employees Want.—To understand the problem of human relations it is necessary to know what management wants in its relation with employees, and what the latter desire. These are summarized as follows:

The employer wants—

1. Industrial peace.
2. Improvement in the quality and quantity of work done.
3. Reduction in cost, not by lower wages nor by skimping the work, but by improved methods.
4. Higher efficiency on the part of the employee.
5. Attentiveness and interest of the worker in his work and in his fellows.
6. Loyalty and confidence on the part of the employee.

[3] Statement by Dr. Harry M. Gage, President of Coe College, Cedar Rapids, Iowa.

The employee wants—[4]

1. Security of job and income.
2. A fair wage for the work done.
3. Safe, orderly, and efficient workplaces and conditions.
4. Pride in the products, policies, and progress of the company for which he works.
5. Reasonable working hours.
6. An understanding of the company's business in so far as his interests are concerned.
7. An opportunity to express his thoughts concerning his job and his relations with the business.
8. Some financial security against the hazards of sickness, accident, disability, death, and old age.

The wants of both groups can be obtained by cooperation, confidence, and persistence.

The Capitalistic System.—Under any form of social or political organization people must work together according to some plan. This implies the acceptance of leadership and direction. Certainly, individual, uncoordinated activity means chaos. In business and industry it is essential that the organization structure result in the maximum production of useful goods and services, for upon this result largely depends the progress of mankind. In this respect the capitalistic system has so operated in America as to furnish to the people as a whole, the greatest material benefits and opportunity for education known in history. It has weaknesses, but many are those inherent in any human organization.

The human relations problem has two phases—the economic and the administrative. Sam A. Lewisohn writes:

> The economic phase includes such matters as wages and may be regarded as peculiar to our present economic system, while the administrative phase is the permanent problem of organizing human nature and has nothing specific to do with any particular system. There is a great deal that is purely administrative which an employer must do in running a large plant. Such problems are of almost exactly the same nature as those presented in any other non-economic organization, such as the Red Cross and the Army organization, which involve problems of leadership but do not involve any particular economic problems. . . .
>
> There are elements in the personal make-up of forceful employers which have nothing to do with capitalism and which are the attributes of an administrative leader in any active organization. An outstanding trait is

[4] "After All—Employees Are Just People," by Ralph A. Lind, *Factory Management and Maintenance*, Vol. 92, No. 2, p. 57.

impatience with interference in control. There is a natural autocracy of leadership. . . . There is a growing recognition on the part of those in positions of authority, however, that they can obtain better results by enlisting the cooperation of those that they lead rather than by insisting upon their own infallibility.

There are desires of the workman that are not strictly economic but which are found among subordinates working under any administrative system. These desires are the desire for justice, the desire for status, and the desire to have their jobs made into careers. The desire for justice is inherent in human beings. . . . Besides justice, employees desire a certain recognition of their status as independent human beings, and it is for this purpose that managements have established employee representation. . . . Workmen are not different from men in other branches of life. If they are energetic they desire above all things a successful career. It is true there is only a small fraction of workers that desire increased responsibilities, but this fraction must be given opportunity for advancement.[5]

Management recognizes that as a prerequisite to national and individual well-being, harmony and goodwill must exist in our production organizations. Only individuals working harmoniously together get the best results attainable: i.e., maximum productivity of goods and service. This is the objective of leading executives, as it is of trade union leaders. William F. Green, president of the American Federation of Labor, has stated that the worker's welfare is dependent upon greater individual production and the elimination of waste in industry. We must *have,* before we can divide. That our present economic order holds most promise in this direction for the rank and file of American people is the conviction of eminent labor leaders.

Henry Ford points the way toward success for capitalism, when he says that in order to achieve economic plenty for all, industry must produce more.[6]

You cannot spread prosperity by spreading the existing supply of wealth —usable goods—in a thinner and always thinner layer across all the people.

It is silly to talk about reducing production and raising prices as a way to prosperity.

Only by making things can we have enough things for everybody.

We must make better goods less expensively. And we must pay people enough in wages so that they can afford to buy the things they make.

Modern machinery makes employment by bringing manufactured goods down to a price within the reach of the buying public.

[5] "Basic Principles of Managing Men," by S. A. Lewisohn, Executives' Service Bulletin No. 8, Metropolitan Life Insurance Company.

[6] "Industry Must Make More of Everything," an interview with Henry Ford by Arthur Van Vlissingen, *Factory Management and Maintenance,* Vol. 94, No. 9, p. 36.

The progress being made in increasing the well-being of individuals by progress in production is indicated by the lower prices for many products, such as electric refrigerators, radios, automobiles, and the like. Prices of the former items have been lowered as much as 50% within a few years, while automobiles cost considerably less. At the same time values have been increased. Articles of this kind are not possessed by working people abroad.

In order to make business and industry serve the people of a nation effectively under capitalism, the task is to find an equitable balance between the cost of labor, the price of the commodity in the market, and a profit adequate to make the enterprise attractive to capital. And beyond this question is the necessity of maintaining a high standard of living for a free people. The real wage level of the United States is from two to four times greater than that of other countries. It is clear, therefore, that the capitalistic system of production and modern production arrangements have proved effective, and further, that the benefits enjoyed accrue largely to the wage earners.

LABOR ORGANIZATIONS

Union Problems.—Early efforts toward unionization of workers were due to local differences between employees and employers. They became an agency for the settlement of problems of human relations arising in connection with economic activities, principally manufacturing. Unions are in part a consequence of unintelligent and unfair treatment of employees in the past. They have been protective organizations, constructed for defensive and offensive fighting in the economic interests of members. Union insistence upon better working conditions, shorter hours of employment, increased wage rates, fair dealing with individuals, and recognition of the worker as a social unit has been of immeasurable value to all working people. Samuel Gompers, for 42 years president of the American Federation of Labor, expressed the aims of labor organizations succinctly when he said they strive to secure "more" for the worker. Always more money and better working conditions.

Unions have been fighting organizations, often necessarily so, designed to get the worker a real or imagined share of industrial profits, and with little regard for the interests of management, owners, or the public. Union leadership, broad-minded and admirable as it has been in a few cases, has too often, especially among subordinates, been unintelligent, narrow, and even unscrupulous. The strength of unionism has depended upon the solidity of the group. To this end class differences frequently have been

fostered, and efforts made to keep alive the false idea of opposing interests of men and management.

The American Federation of Labor.—Efforts to foster social and political aims in labor movements proved unavailing. In 1886 the American Federation of Labor was organized to promote the economic welfare of its members, and since that time it has been the dominant influence in the field. Its plan of organization consists of unions organized mainly on a craft basis, united in a federation. Its leadership has remained conservative, non-partisan, depending upon voluntary membership rather than upon compulsion throughout its history. Its strength and its weakness have been the autonomous character of its constituent unions. For whereas the independence of the unions makes for democracy and flexibility, it often also results in corrupt leadership, in racketeering, and in practices which lead to public disapproval. Some craft unions have remained independent of the American Federation of Labor, as the various Railroad Brotherhoods.

The Congress of Industrial Organizations.—In 1935 John L. Lewis and a few other labor leaders became dissatisfied with what they considered reactionary and outmoded policies in the A. F. of L. They set about to establish industrial unionism in the country with the formation of the Committee for Industrial Organization—later changed to Congress of Industrial Organizations. The object of the C. I. O. was to organize unions along industrial rather than craft lines. For example, all employees in the automobile industry would belong to the union of automobile workers, regardless of the kind of work they performed. This was thought to be more in line with modern productive organization. The C. I. O. aggressively organized employees in both large and small plants. Its efforts were often marked by violence and coercion, and in some cases the use of political influence was charged. A bitter factional dispute soon developed between the A. F. of L. and the C. I. O., causing a split in the ranks of labor. At times the fight between the two organizations became more intense than their battle for the rights of labor. Unfortunately in order to gain its ends the C. I. O. has used rabble-rousing tactics, and sowed the seeds of class dissension. Its leaders have frankly sought political influence and power.

The A. F. of L. contends that compulsory unionism will fail, that the diverse interests within an industrial union lead to dissension and weakness, and that the organization of a labor party or alignment with an established political party is an error. But the C. I. O. is the first national union that has successfully organized labor in our large industrial plants.

Strength of Unions.—The majority of American workers are not labor union members despite the National Labor Relations Act. They evidently feel the cost in initiation fees, dues, and other contributions is too great. Unionism reached a peak of about 5,000,000 members in 1920, the only time previous to 1936, with approximately 36,000,000 workers eligible. In the manufacturing industries voluntary unionism enlisted less than 10% of the workers engaged. The strength and trend of membership in the American Federation of Labor are indicated by the following data:

MEMBERSHIP IN THE AMERICAN FEDERATION OF LABOR *

Year		Membership
1924		2,865,799
1926		2,803,966
1928		2,896,063
1930		2,961,096
1932		2,532,261
1934		2,608,011
1936		3,442,398
1938		3,623,087
1940		4,374,700
1942		5,482,581
1944	(Approx.)	6,807,000
1946	(")	6,000,000

* Includes some Canadian membership.

The membership in all United States unions has varied as follows:

MEMBERSHIP IN ALL NATIONAL UNIONS

Year	Membership
1929	3,442,600
1933	2,973,000
1936	4,700,000
1940	8,500,000
1942	12,000,000
1944	13,750,000
1946	13,000,000

The C. I. O. has had a rapid growth and its membership has fluctuated greatly. It has a claimed membership of over 6,000,000, but its dues-paying members may be less. Authoritative information is lacking.

Economic and Social Effect of Unions.—Union enthusiasts assert that with the unionization of all workers, and unions universally recognized, these organizations would immediately become cooperative, constructive organizations, helpful in furthering the interests of all, and solve the problem of human relations. This is questionable, if experience abroad, particularly in England and Australia, is of value. Closer to

home, we have unionized industries in the United States which might be expected to serve as examples of this tendency, but do not.

In the American anthracite coal industry, 100% unionized, union influence has been negative. In the bituminous fields, with a powerful organization, unions have not contributed to a solution of the problems of operation, and have been neglectful of public interest. In the building trades which have been strongly organized, inter-union conflicts have been frequent, and union policy unmindful of public welfare. Strongly intrenched unions have signally failed to win public confidence and regard, or the endorsement of the industry.

Some unions have been constructive and helpful to management, particularly in recent years. Examples are those in the printing trades and the garment makers. Still others occupy a middle ground with regard to cooperation.

As previously pointed out, unions influence wages, hours of work, and working conditions. Does this influence add to average incomes, improve employment, or increase purchasing power? Are unions helpful in bringing about lower prices to the consumer? Allen W. Rucker, in a book entitled, "Labor's Road to Plenty," analyzes the end results of union activity in several major industries. His conclusion is that unionization is detrimental to the interests of both labor and the public. The data in Table 10 are typical of those presented, and are supposed to show the effect of union activities during periods of both prosperity and depression. While the conclusions may still be the subject of controversy, the figures given furnish some interesting material.

It will be noted that according to Mr. Rucker's index figures the average annual income, employment, and purchasing power of payrolls in six nonunionized light industries are in all cases higher upon a 1923 base than are those of six unionized light industries. A comparison of the figures for particular industries between the prosperity year of 1929 and the depression year of 1933 shows that the economic cycle does not treat all industries or industrial workers alike. It will be well worth while to keep data over a longer period in order to check results.

Manufacturing companies are in the business of producing goods for public consumption. Labor and other costs are necessarily included in prices. The consumer must pay all costs; there is no other way. When prices are high and the public does not buy, the situation is reflected in less employment and purchasing power. High wage rates and labor practices which hamper production tend to increase prices unless savings can be made in other items. Some unions have aided management in finding these other savings, but labor generally has not considered this

TABLE 10. TREND OF AVERAGE ANNUAL INCOMES, OPPORTUNITY FOR EMPLOYMENT, AND PURCHASING POWER OF TOTAL PAYROLLS IN THIRTEEN MAJOR INDUSTRIES *

1923 = 100.0

	Annual Income 1929 Per Cent	Annual Income 1933 Per Cent	Employment 1929 Per Cent	Employment 1933 Per Cent	Purchasing Power 1929 Per Cent	Purchasing Power 1933 Per Cent
Anthracite coal mining	80.5	58.7	96.0	66.3	81.2	49.8
Bituminous coal mining	89.4	40.6	71.4	59.4	67.0	33.9
Boot and shoe manufacturing	97.3	66.9	91.3	84.8	93.3	79.8
Cotton textile manufacturing	90.7	67.8	90.1	80.5	85.8	76.8
Knit goods manufacturing	116.7	80.4	107.3	97.7	131.5	110.4
Glass manufacturing	106.0	76.1	92.1	67.9	102.5	70.7
Leather manufacturing	102.8	78.9	83.6	74.0	90.2	82.1
Men's clothing manufacturing	91.6	59.1	94.7	75.4	91.1	62.6
Printing and publishing	107.0	83.4	113.6	79.5	123.9	103.1
Railway repair shops	108.0	78.8	75.5	54.8	85.6	51.0
Railway transportation	107.9	89.4	89.4	52.3	101.2	65.7
Ship building	110.0	75.3	98.4	49.1	102.1	52.5
Silk and rayon manufacturing	104.1	66.3	104.2	88.1	113.8	82.2
Average for six unionized light industries	98.2	68.3	94.7	83.8	97.7	80.4
Average for six nonunionized light industries	106.2	79.7	110.8	94.5	123.7	106.0
Average for all manufacturing	104.8	69.3	100.2	68.8	111.8	65.4

* Labor's Road to Plenty, by Allen W. Rucker, Ch. 7.

problem as any of its affair. Union leaders have claimed that with greater unionization more cooperation between management and labor will be achieved. It is to be hoped this will be the outcome, for it is one of the major contentions of true scientific management.

Effect of Total Unionization.—There are about 50,000,000 wage earners in our working population, excluding children, housewives, and the aged. Of this number, about 14,000,000 are in the manufacturing and mechanized industries, and about 8,500,000 are wage earners in factories. The national income was 37 billions in 1932 and 89 billions in 1929. It is distributed in salaries, wages, dividends upon investments, interest for savings, etc. Only about one-tenth normally goes to those earning over $5,000 a year. Assuming that a 60-billion dollar national income is distributed entirely to wage earners, the average income would be about $1,200 a year. The futility of universal unionism as a means of raising wages is apparent. "If all industry were unionized, the apparent gains of each union would be neutralized by similar gains by all the others. As a net result, real wages would be the same as now. Unionized industry

could gain an advantage in only one way—that is by forcing other groups, such as farmers, white collar workers, professional people, to pay an uneconomic price for the products of industry." [7]

The Future of Unions.—Management must necessarily deal with labor collectively, and labor must have a medium for group expression. With upwards of 10,000,000 organized into unions of all kinds, the movement is one of vital public importance. In their influence upon public well-being they may be compared in some respects to business corporations. This suggests increasing legislation, direction, and control. Monopoly in any form is objectionable. Violence, coercion, and compulsion of employers or employees have no place in a democracy. As policies and procedures advocated or practiced are revealed to be economically and socially unsound, there must be ways of protecting the public interest. The racketeering and criminal element must be eliminated from the labor movement. Issues to be dealt with include (1) the closed shop, (2) the check-off, (3) picketing, (4) strikes, (5) incorporation of unions, (6) public records of union activities and use of funds, (7) limitation of use of funds for political purposes, (8) responsibility of union for acts of its officers and members, and (9) compulsory unionism. Recent legislation in Oregon, Minnesota, Michigan, and Wisconsin indicates public objection to radical labor activities and practices which are hindering to trade and commerce. Southern states guarantee constitutional industrial freedom to business. Public sentiment will finally determine the place of unions in our society. Labor needs enlightened leadership to keep the gains already secured without arousing the public hostility that may make itself apparent at any time.

Independent Unions.—Employee representation plans appeared early in the century, but were not numerous until the years of unusual manufacturing activity from 1915 to 1919. In 1926, there were 432 such plans, with 1,369,000 employees participating. The passage of the National Industrial Recovery Act in 1933 gave a further impetus to this movement, as workers were encouraged to associate in collective bargaining agencies. However, the National Labor Relations Board interpreted the Wagner Act of 1935 as implying that these plans constitute unfair labor practices because of supposed employer domination. Several were disbanded, while others continued as independent unions without any company aid or assistance. They are legal when organized and carried on by employees entirely independent of the employer. Although vigor-

[7] Royal F. Munger, writing in the *Chicago Daily News*.

ously opposed by the national labor unions, independent unions are still being established and are favored by many employees.

The independent union carries with it the idea of a mutuality of interest between workers and management, and fewer labor disputes occur when this idea is present. The worker is entitled to a presentation of his views through some representation plan that will protect his interest, and he is entitled to choose whatever form he prefers; but he should be sure the union is strong enough to enforce its demands.

Independent unions offer opportunity for consultation, negotiation and friendly cooperation between those whose primary interests are the same. They give the workers a chance to be heard, and mutual understanding and agreement generally follow. They eliminate outside labor agitators, the spirit of force, a divided loyalty, and the necessity of participating in labor difficulties elsewhere.

Ordinarily 75% to 80% or more of the propositions submitted to joint shop committees are settled without appeal to higher bodies. Objection may be offered that the employees do not get all they ask for, and that important demands are overruled. However, experience shows that agreement satisfactory to both parties is likely to be arrived at. In this connection the fact that unions fail to achieve all objectives aimed at, the cost of union membership and strikes must be considered. The wide range of subjects covered by the questions brought to the attention of management by employees of the steel industry is shown by the following table which classifies the subjects under discussion during a six-month period.[8]

Wages and hours of work	2,063
Safety	629
Conditions affecting production and comfort	383
Methods and economics	149
Health and sanitation	209
Employees' transportation	63
Pensions and relief	195
Housing and living conditions	44
Education and recreation	108
Dismissals and alleged discriminations	21
Rules, ways, and means	75
Miscellaneous	1,197
	5,136

Seventy-five per cent of these questions were decided in favor of employees, 18% in favor of management, and the remaining 7% were compromised or withdrawn.

[8] From *Steel Facts*, published by the American Iron and Steel Institute, New York.

If employers misuse their power of ownership they will defeat their own ends as lamentably as some unions have done in permitting selfish and autocratic strikes and hindering progressive management.

Independent unions are formed by employees in a single plant, or the several plants of one concern. The organization may be one which the new worker joins, paying nominal dues, or he may automatically acquire rights of membership with a limited term of service. Foremen may be ineligible for membership. Officers are elected and committees appointed to effect a working organization, and one which can adequately represent the workers' interests in negotiations with management.

CHAPTER 19

THE PERSONNEL DEPARTMENT—EMPLOYMENT AND ECONOMIC SECURITY

Objectives of Personnel Management.—The objectives of a personnel or industrial relations department may be stated as follows:

1. To increase the efficiency of the working force—increase production and sales, improve service, decrease costs, maintain or improve quality.
2. To increase the satisfaction and morale of all employees.
3. To protect the physical and mental well-being of employees.

These objectives must go hand-in-hand. Any improvement in efficiency which is achieved at the expense of lowered morale or the physical impairment of employees will in the long run prove costly. Likewise, any personnel activities which do not improve efficiency either directly or indirectly will be uneconomical. Sound industrial relations are a matter of sound business and not of paternalism or welfare.[1]

Personnel departments strive to treat employees as individual personalities. They recognize that management and employees are in the same business, dependent upon its success in which they share. A personnel department which endeavors to cooperate with its personnel to the end that each person may develop and utilize to best advantage his talents and capabilities, provide adequately for his family, and serve his community usefully as a citizen, is building for the future.

Personnel Policies.—The following policies were formulated some twenty-five years ago by the Western Electric Company for the guidance of those directing the work of others. They have stood the test of time.

1. To pay all employees adequately for services rendered.
2. To maintain reasonable hours of work and safe working conditions.
3. To provide continuous employment consistent with business conditions.
4. To place employees in the kind of work best suited to their abilities.
5. To help each individual to progress in the company's service.

[1] "Fundamentals of a Personnel and Industrial Relations Program," by Harold B. Bergen, *Personnel*, Vol. 13, No. 2.

6. To aid employees in time of need.
7. To encourage thrift.
8. To cooperate in social, athletic and other recreational activities.
9. To accord to each employee the right to discuss freely with executives any matters concerning his or her welfare or the company's interest.
10. To carry on the daily work in a spirit of friendliness.

The Evolution of Personnel Work.—Major interest in personnel work was manifested first about 1914. The European war so greatly increased the demand for goods, that workers became increasingly difficult to obtain and more difficult to keep on the job. Executives began to recognize that an annual labor turnover of 300% meant also a cost of from $10 to $300 per replacement, and with men who had little enthusiasm for their jobs, a tremendous expense and waste. Those concerns with personnel departments well established were observed to be successful in retaining their staffs and maintaining effective production organizations. As all found it essential to be able to attract and hold workers, such departments were very generally created.

Personnel departments of this period were often merely employment departments, designed to find workers and do what was necessary under the circumstances to keep them. The executives in charge were frequently inexperienced and poorly qualified. Many employers were without faith in the soundness of the movement, and insincere in attempts to promote employee well-being and plans of representation. As a consequence many failures resulted. To the extent that intelligent direction was exercised, and sound methods and policies carefully worked out under the guidance of able executives desirous of creating new and better relationships with employees, the movement succeeded.

Departmental Activities.—In Figure 95 the activities of an industrial relations department are outlined. The company also fosters and promotes recreation, education and entertainment activities through the agency of the Hawthorne Club. This organization composed of all employees carries on some 30 activities. A large, well-equipped gymnasium and athletic field are provided.

Each company develops its personnel department to meet its individual requirements, but the following divisions of work are typical: (1) employment procedure, (2) economic security, (3) education and training, (4) recreation and entertainment, (5) health and safety, (6) joint relations, and (7) restaurant service and plant conveniences. The Caterpillar Tractor Co. has organized its industrial relations work

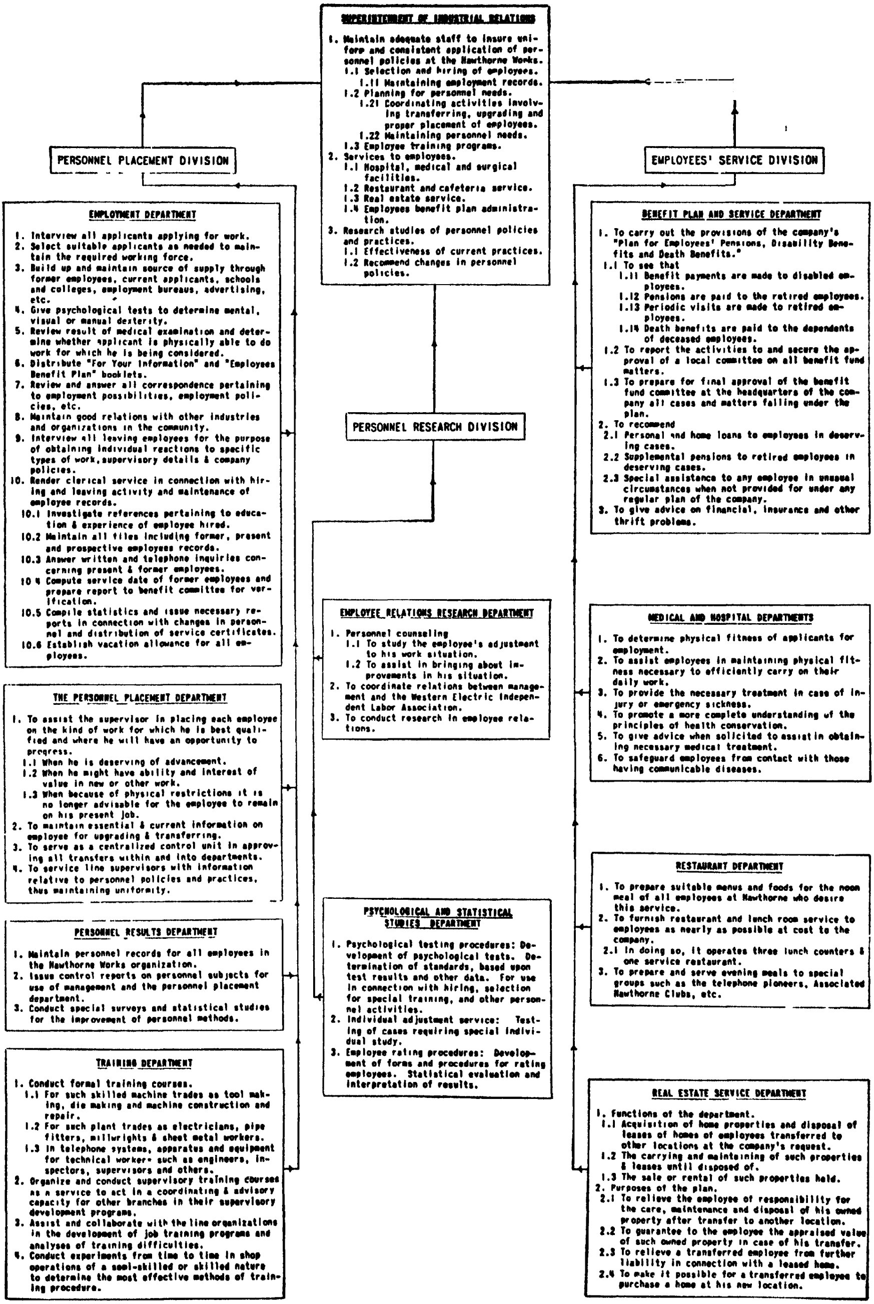

Figure 95. Organization Chart of the Industrial Relations Department of the Hawthorne Works, Western Electric Company

into divisions as follows: (1) personnel, (2) medical, (3) safety and sanitation, (4) insurance, (5) training, (6) publications, and (7) restaurant. The director in this case helps formulate and give effect to policies, and with staff assistance carries on cost of living surveys, and wage and salary studies. In all cases the organization and administration of the various activities is centralized in one department.

EMPLOYMENT PROCEDURE

Since industry is a phase of the contemporary social system, the function of the employment division is twofold. First, it seeks to help workers find work which they can do well, enjoy, and which will enable them to live the sort of life they desire. Second, the employment division endeavors to obtain for its company a man who can perform or learn to perform the duties demanded by a particular occupation. This is a clear illustration of the way in which the welfare of the individual and the industrial organization are interrelated.

Functional Organization.—Centralized responsibility for hiring and termination of employment is an accepted principle in most medium-sized and large companies today. The foreman does not possess the qualifications of an employment executive, the time, nor the facilities necessary to perform the task adequately. In this field as in others expertness pays dividends. From a company standpoint, general qualifications are as important as proficiency at a given task. Further, several definite evils manifest themselves when foremen control employment. These are favoritism, the employment of relatives, inequitable promotions and wage rates, the formation of cliques, and increased labor turnover, with inevitable loss of good workers.

With centralized administration applicants may be selected who are acceptable from the standpoint of health, age, mental and physical characteristics, moral and social qualifications, past record, and craft skill. Favored applicants may then be referred to the foreman, whose final approval is necessary. The foreman likewise retains the privilege of dismissing workers from his department for cause, and thus retains the prestige essential to control of the group for whose output he is responsible. When a desirable employee fails to make good in one department, a very definite effort should be made to place him satisfactorily at some other point in the organization.

The Interview and Application Blank.—The personal interview supplemented by the application blank and its data are considered indispensable parts of employment procedure. (See Figures 96a–b.) Infor-

APPLICATION FOR EMPLOYMENT

CATERPILLAR TRACTOR CO.

FORMER EMPLOYEE YES ☐ NO ☐ DATE __________ 19____

NAME __________ (Last) __________ (First) __________ (Middle) SOCIAL SECURITY NO. __________

ADDRESS __________ (Street and Number) __________ (City) __________ (State) PHONE NO. __________

DATE OF BIRTH __________ (Month) __________ (Day) __________ (Year) WHERE BORN __________ (City) __________ (State or Country)

WHERE FATHER BORN __________ (State or Country) WHERE MOTHER BORN __________ (State or Country)

NATIONALITY OF FATHER __________ NATIONALITY OF MOTHER __________

ARE YOU: (Check) SINGLE ☐ MARRIED ☐ SEPARATED ☐ DIVORCED ☐ WIDOW OR WIDOWER ☐

NUMBER DEPENDENT UPON YOUR INCOME: CHILDREN __________ RELATIVES __________ OTHER __________

DO YOU: (Check) OWN HOME ☐ RENT ☐ BOARD ☐ ROOM ☐ LIVE WITH RELATIVES ☐ DO YOU OWN A CAR? YES ☐ NO ☐

RESIDENT IN PEORIA COMMUNITY SINCE __________ 19____ ARE YOU A U. S. CITIZEN? YES ☐ NO ☐

HEIGHT ____ (Feet) ____ (Inches) WEIGHT __________ (Pounds) COLOR EYES __________ COLOR HAIR __________

CONDITION OF HEALTH: (Check) EXCELLENT ☐ GOOD ☐ FAIR ☐ HAVE YOU EVER HAD TROUBLE WITH HEART? ____ LUNGS? ____ HERNIA? ____ (Answer Yes or No)

HAVE YOU ANY PHYSICAL HANDICAPS TO SIGHT? ____ HEARING? ____ SPEECH? ____ HANDS? ____ FEET? ____ (Answer Yes or No)

OTHER AILMENTS OR DISABILITIES __________

HOW MUCH TIME HAVE YOU LOST THROUGH ILLNESS DURING THE LAST TWO YEARS? __________

CHECK HIGHEST GRADE COMPLETED: GRAMMAR SCHOOL ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 HIGH SCHOOL ☐1 ☐2 ☐3 ☐4 COLLEGE ☐1 ☐2 ☐3 ☐4

IF YOU ATTENDED COLLEGE, GIVE: NAME AND LOCATION __________

ATTENDED FROM ____ (Year) TO ____ (Year) COURSE OF STUDY __________ DEGREES __________

OTHER TRAINING __________

____

WHAT FOREIGN LANGUAGES CAN YOU READ? __________ SPEAK? __________

CAN YOU READ BLUEPRINTS? ____ (Answer Yes or No) MICROMETER? ____ SLIDE RULE? ____

WHAT ARE YOUR HOBBIES? __________

APPLICANT DOES NOT FILL IN SPACES BELOW

APPLICATION RECEIVED __________ 19____ SOURCE __________

R. B. __________ INTERVIEWED BY __________

FIRST CHOICE __________ SECOND CHOICE __________

REMARKS __________

__________ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ TOTAL ____

DATE EMPLOYED __________ 19____ JOB CLASS __________

DEPT. NAME __________ DEPT. NO. ____ SHIFT ____ RATE ____

EMPLOYED BY __________ APPROVED BY __________

Form 5167

INFORMATION FOR APPLICANT

Your Application for Employment will be carefully filed and you may be assured that you will receive prompt notification when an opening occurs for one of your qualifications. Selection of applicants will be made entirely from our file, and all notifications of employment opportunity will be by letter.

Your application will remain active for a period of ninety days from date, but may be renewed as many times as desired. To renew your application for an additional ninety day period, we prefer that you write us a letter and simply state that you wish to have your application renewed. You may be certain that upon renewal your application will remain before us for the additional period. If not renewed at the expiration of the ninety day period, your application will be destroyed. Renewal letters will not be acknowledged.

When opportunity for employment occurs, preferred consideration is always given to our former employees.

Kindly advise us if you change your address. Address all communications to the PERSONNEL DIVISION.

DATE __________ INTERVIEWER __________

Figure 96a. Application Blank of the Caterpillar Tractor Co.

RECORD OF PREVIOUS EMPLOYMENT

LIST MOST RECENT EMPLOYMENT FIRST

NAME OF EMPLOYER ____________

STREET ADDRESS ____________ CITY AND STATE ____________

EMPLOYED AS ____________

LENGTH OF SERVICE ____________ DATE LEFT ____________ CLOCK NO ____________

REASON FOR LEAVING ____________

NAME OF EMPLOYER ____________

STREET ADDRESS ____________ CITY AND STATE ____________

EMPLOYED AS ____________

LENGTH OF SERVICE ____________ DATE LEFT ____________ CLOCK NO ____________

REASON FOR LEAVING ____________

NAME OF EMPLOYER ____________

STREET ADDRESS ____________ CITY AND STATE ____________

EMPLOYED AS ____________

LENGTH OF SERVICE ____________ DATE LEFT ____________ CLOCK NO ____________

REASON FOR LEAVING ____________

OTHER EXPERIENCE NOT SHOWN ABOVE ____________

LIST IN ORDER OF PREFERENCE TYPE OF WORK FOR WHICH YOU ARE QUALIFIED OR MACHINE WHICH YOU CAN OPERATE ____________

RELATIVES EMPLOYED BY CATERPILLAR TRACTOR CO

THIS INFORMATION IS DESIRED ONLY FOR THE PURPOSE OF MAKING PROPER PLACEMENT WE DO HIRE RELATIVES

NAME	POSITION	RELATION

In signing this Application for Employment it is done with the understanding that my previous and present employers will be asked for information relative to my employment record with them and I hereby release from all liability or damage those individuals or corporations who provide such information

SIGNED ____________
Applicant

Figure 96b Reverse of Application Blank of the Caterpillar Tractor Co

mation supplied on the application blank will aid the interviewer in judging the acceptability of the applicant, and with the job specification card will form a basis for questioning. With experience the skillful employment man will make few mistakes when he has the opportunity to meet and talk with applicants in this intelligent and intimate fashion. He will need to possess a friendly, tactful nature and be capable of gleaning from the applicant all necessary information without embarrassing or antagonizing him. The interview should be conducted in private, and whether or not work is in prospect for the applicant, he should be accorded cordial and courteous attention. The validity of statements made on the application blank may be checked later if the individual becomes an employee. When this is the known practice few cases of misrepresentation will occur.

Job Specifications.—As above indicated, the interviewer should be provided with job specification cards outlining clearly and completely the main requirements of each job for which workers are to be chosen. These are a result of job analysis procedure which may be done by this department, but is sometimes cared for by the motion and time study division. (See Figures 108a and 108b, pages 376–377.)

Intelligence Tests.—Intelligence tests aid in judging a person's aptitude and fitness for particular tasks. "They measure a combination in unknown proportions of native and acquired ability, and the scores made are more or less influenced by school training. They possess value in indicating the probable relative native abilities of individuals who have experienced about the same environment and school opportunities." [2] Thus, they are helpful in indicating individuals of most promise, aid in placing them in suitable occupations, and serve as a guide for promotions.

Tests of this character do not measure reliability, honesty, loyalty, capacity for leadership, and similar traits. Other things being equal, however, the person most likely to succeed in a given line of work will be indicated by an intelligence test and should be chosen. Frankly recognized as still in the experimental stage, such tests must be used with judgment. Failure to recognize a good man may cause him to seek a greater opportunity elsewhere, and such losses are to be avoided.

Trade Tests.—Trade tests are more definitely indicative and final. An accurate estimate of the worker's skill and familiarity with the trade can be judged by his answers to skillfully prepared questions covering

[2] Statement of C. W. O'Dell, Assistant Director of the Bureau of Educational Research, University of Illinois.

equipment, tools, and practices. He may be asked to identify machine parts and tools on photographs. Tasks can also be assigned. Each craft occupation has a lingo of its own which often serves to identify the experienced and qualified man.

Aiding the New Employee to Become Established.—It should be a part of the foreman's task to make the new employee feel at home by acquainting him with his fellow workmen, and by friendly attention and instruction while he is adjusting himself to a new environment. The personnel department may well follow this up in a month by a personal interview.

The new worker should also be acquainted with the various personnel department activities, the plan of employee representation, opportunities afforded for recreation, education, saving, insurance, and the like. He must be made to feel that he is a part of the "outfit," and imbued with its aims and purposes. Helpful in accomplishing this are booklets of instruction for employees. These manuals outline the history of the company, give company rules, privileges granted, and other useful information. It is a good idea to have some qualified employee conduct new workers about the plant before they begin work or soon afterward, so that they can see for themselves what is being done and comprehend their place in the scheme of things. Sometimes an elderly or retired workman, ripe and mellow with age, is most suitable for this task. Talks by executives may be fitted into educational tours of this kind.

Employee and Other Records.—In order to operate effectively the employment division of the personnel department must have adequate employee records, statistical information, and economic data as a basis for its actions.

A record of the placement of each man may be kept on a printed form, which provides space for recording transfers and promotions. At intervals of six months a review of the employee's record should be a matter of routine, with consideration of a wage increase, and perhaps a talk with him about his work and the future. Pertinent facts and conclusions should be recorded.

In addition to the complete employee records suggested, an audit of the plant's future needs and of the community labor supply is invaluable. Forecasts of business activity can be interpreted in terms of personnel requirements for stated periods, and thus needs anticipated.

Information pertaining to the cost of living, wage trends, both real and actual, business conditions tending to attract labor elsewhere, changes in the labor supply, market conditions affecting distribution of product,

reports concerning personnel activities, experience and results of practice in other plants all have a logical place in the department files.

Sources of Labor Supply.—A labor audit will disclose the community labor resources. Employees will suggest the names of friends, relatives, and others whom they can recommend, and this constitutes an excellent source of worker material. It often happens that workers living nearby are employees of a distant factory, and vice versa. Intelligent adjustment of this situation in cooperation with other plants is beneficial to all parties.

Other sources of labor supply are high schools, manual training schools, approved employment bureaus, and newspaper advertising. The latter medium should be used with caution and care taken not to take employees from other local plants without good cause. Cooperation between the industries, or like industries of a locality, in building up and maintaining a satisfactory labor supply is constructive employment department procedure.

Promotions and Transfers.—The placement of a worker marks the beginning of the personnel department's interest in his behalf. In a month's time he should be interviewed to assure that he is adjusted to his work and satisfied. At regular intervals, as before suggested, each employee should be given individual consideration, and reports of the foreman should be used in evaluating his worth, as a guide to merited promotion. The ambitious worker must not be forgotten or permitted to remain in work which does not have a future for him.

Workers are entitled to make progress. Lack of ability or the necessary qualifications should be the only obstacle. When a worker is capable of performing more important tasks than his department has to offer, there should be opportunity for transfer, or the worker aided to better himself elsewhere.

Merit Rating.—Merit rating report forms are usually developed by companies to meet individual needs and are a product of the thought and ideas of those immediately concerned. This procedure accounts for the lack of uniformity in the forms used. The fact that merit rating plans are evolved from mental effort and discussion by those applying them contributes to their effectiveness, because it assures greater understanding of their purpose and value, interest, and cooperation. Figure 97 illustrates a form for hourly rated workers in the factory.

A suggestion for rating new workers is given in Figure 98. This plan is applicable to office employees as well as factory workers and gives con-

EMPLOYEE'S RATING CHART
AC SPARK PLUG DIVISION
GENERAL MOTORS CORPORATION

DATE ________ EMPLOYEE'S NAME ________ (FIRST) ________ (MIDDLE) ________ (LAST) CLOCK NO. ________

RATING FOR PERIOD FROM ________ TO ________ OCCUPATION RATED ON ________

QUALITY RATED	DETAILS OF QUALITY	UNSATISFACTORY NEGATIVE QUALITIES		AVERAGE	SATISFACTORY POSITIVE QUALITIES		DETAIL TOTAL	QUALITY TOTAL	REMARKS
		PUT CROSS IN SECTION WHICH MOST ACCURATELY DESCRIBES DETAIL IN THIS EMPLOYEE							
QUALITY OF WORK	ACCURACY OF PRODUCTION	MANY ERRORS & SPOILED WORK 4	CARELESS 2	AVERAGE 6	CAREFUL 2	MOST ACCURATE 4			
	CARE OF WORKING SPACE	SLOVENLY 2	CARELESS 1	AVERAGE 3	KEEPS SPACE CLEAN 1	VERY CLEAN AND ORDERLY 2			
	HANDLING OF MATERIAL	ROUGH 2	CARELESS 1	AVERAGE 3	CAREFUL 1	VERY CAREFUL 2			
QUANTITY OF WORK	SPEED OF PRODUCTION	VERY SLOW 4	SLOW 2	AVERAGE 6	FAST 2	VERY FAST 4			
	USE OF WORKING TIME	VERY WASTEFUL 2	LOAF WITH OTHERS 1	AVERAGE 3	GOOD 1	VERY BUSY 2			
	USE OF MATERIALS	EXTREMELY WASTEFUL 2	CARELESS 1	AVERAGE 3	GOOD 1	VERY CAREFUL & CONSIDERATE 2			
ABILITY TO DO OTHER WORK	ABILITY TO LEARN	DULL 1½	LEARNS SLOWLY ½	AVERAGE 2½	LEARNS QUICKLY ½	BRILLIANT 1½			
	ACCEPTANCE OF RESPONSIBILITY	BUCK PASSER 1	EVADES IT ½	AVERAGE 1	LIKES IT ½	SEEKS IT AND HANDLES IT WELL 1			
	INITIATIVE	LIVES IN A RUT 1	SELDOM OFFERS SUGGESTIONS ½	AVERAGE 1	RESOURCEFULLY SUGGESTIVE ½	VERY ORIGINAL 1			
	ABILITY TO DIRECT THE WORK OF OTHERS	ANTAGONIZES 1	HINDERS ½	AVERAGE 1	HELPS ½	EXCELLENT LEADER 1			
ATTENDANCE		VERY POOR 4	POOR 2	AVERAGE 6	GOOD 2	EXCELLENT 4			
CO-OPERATION	ATTITUDE TOWARDS COMPANY	ACTIVELY ANTAGONISTIC 2	PASSIVELY ANTAGONISTIC 1	NEUTRAL 3	CO-OPERATES PASSIVELY 1	CO-OPERATES ACTIVELY 2			
	ATTITUDE TOWARDS SUPERIORS	DISREGARDS WISHES 1	FOLLOWS ORDERS LIKE SOLDIER ½	NEUTRAL 1½	FOLLOWS ORDERS CHEERFULLY ½	TRIES TO HELP MAKE GOOD 1			
	ATTITUDE TOWARDS FELLOW WORKMEN	PUTS BLAME FOR ERRORS ON THEM 1	LOOKS DOWN ON THEM ½	NEUTRAL 1½	HELPS THEM WHEN TOLD ½	EXTREMELY CONSIDERATE 1			
SAFETY HABITS	ATTITUDE TOWARDS SAFETY PROGRAM	DESTRUCTIVELY CRITICAL 3	FOLLOWS RULES DISINTERESTEDLY 1½	NEUTRAL 5	OFFERS A FEW SUGGESTIONS 1½	EXTREMELY HELPFUL 3			
	OBSERVANCE OF SAFETY RULES	OPENLY DISREGARDS 3	BELIEVED DISREG DS WHEN NOT WATCH D 1½	AVERAGE 5	OBSERVES ALL MAJOR RULES 1½	OBSERVES ALL AND HAS OWN 3			
	ACCIDENT RECORD	MAJOR INJURIES THRU CARELESSNESS 1½	MANY MINOR INJURIES ½	AVERAGE 2½	FEW MINOR INJURIES ½	NEVER GETS MINOR INJURIES 1½			
PERSONAL HABITS	MORAL CHARACTER	KNOWN VERY BAD 2	QUESTIONABLE 1	AVERAGE 3	GOOD 1	OUTSTANDING 2			
	PHYSICAL CONDITION	VERY POOR 1	MANY MINOR AILMENTS ½	AVERAGE 1½	GOOD ½	VERY GOOD 1½			
	GENERAL APPEARANCE	SLOVENLY AND DIRTY 1	CARELESS ½	AVERAGE 1½	NEAT AND CLEAN ALWAYS ½	EXCEPTIONALLY PLEASING 1			

← TOTAL NUMERICAL GRADING

________ RATED BY—(FOREMAN)

________ ASSISTED BY—(TITLE)

________ CHECKED AND APPROVED BY—(SUPERINTENDENT)

________ NUMERICAL GRADING BY

Figure 97. Employee Rating Card

REPORT OF NEW EMPLOYEES

NAME. SMITH, John ______ DEPARTMENT______ DATE EMPLOYED_

GRADE	NUMERICAL VAL. ASSIGNED TO GRADE	1st MO.	2nd MO.	3rd MO.	4th MO.	5th MO.	6th MO.	7th MO.	8th MO.	9th MO.	10th MO.	11th MO.	12th MO.
EXCELLENT	5												
GOOD	4												
FAIR OR AVERAGE	3												
BELOW AVERAGE	2												
POOR	1												
NAME OF RATOR		SCL	SCL	SCL	SCL		SCL		ALB		ALB		ALB

NOTE
—— INDICATES PRODUCTION EFFICIENCY
- - - - INDICATES SUPERVISORY POSSIBILITIES

FACTORS CONSIDERED IN DETERMINING PRODUCTION EFFICIENCY

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
QUANTITY OF WORK	3	3.	3.	3.5		3.5		4.		4.		4.
QUALITY OF WORK	3	3.5	3.	3.5		4.		4.5		4.		4.5
PERSONAL ASSETS LOYALTY, APPLICATION, INITIATIVE, JUDGMENT, ATTITUDE, DEPENDABILITY	3	3.	4.	3.5		3.5		4.		4.		4.5
AVERAGE	3	3.2	3.3	3.5		3.7		4.2		4.		4.3

FACTORS CONSIDERED IN DETERMINING SUPERVISORY POSSIBILITIES

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
PROGRESSIVENESS AMBITION, APPLICATION, INITIATIVE.	2	2.5	3.	3.5		3.		3.5		4		4.
DEPENDABILITY ACCURACY, ORDERLINESS, THOROUGHNESS	3	3.	3.5	3.5		3.5		4.		4		4.5
LEADERSHIP COOPERATION, PERSONALITY INSPIRE CONFIDENCE	3	3.	3.	3.		3.		3.5		4		4.
ORGANIZING ABILITY SKILL IN ORGANIZING AND ARRANGING WORK	2	2.	2.5	3.		3.5		3.5		4		4.5
EXECUTIVE JUDGMENT SELECTION OF EMPLOYEES, DECISIONS ABOUT WORK	3	3.	3.	3.		3.		3.5		4		4.
AVERAGE	2.6	2.7	3.	3.2		3.2		3.6		4		4.2

Figure 98. Report Form for New Employees

sideration to two qualities: (1) the production efficiency in the present occupation, and (2) the degree of leadership demonstrated.

Labor Turnover.—The cost of labor turnover has been variously estimated at from $10 to $300, depending upon the class of labor and the circumstances incident to its employment. Certain direct costs of the employment department are evident. Indirect costs include expense of training, spoilage, smaller output, less effective use of machinery and equipment, and the possible interruption to production occasioned. At times the annual labor turnover rate has risen as high as 250% or 300% in many companies. Data covering plants in several industries give the following figures.[3]

AVERAGE LABOR TURNOVER

Reasons for Separation	Per Cent
Quits	7.44
Discharges	1.32
Layoffs	40.44
Total	49.20

Discharges are becoming fewer due to more careful selection of employees, a changing attitude toward unionization as well as an increase in union strength, and a realization of social responsibility. Layoffs because of varying production schedules are less in number, but still a serious problem.

Stabilization of employment has a beneficial effect in increasing the grade of employees and improving worker morale and effectiveness. Lack of a steady job has been one of the worker's chief worries. Certain separations are recognized as normal and to be expected, but the employer may well note how his "quit" rate compares with that of other progressive firms. Any differences should provoke inquiry. Personnel relations work should have a pronounced effect in decreasing the rate of labor turnover.

The Exit Interview.—It is a growing practice for the personnel department to interview employees who leave as well as those who apply for work. Workers who leave may do so for reasons which the company would like very much to know. Valuable information may be obtained at this time on the attitude of the employees toward the company and its employment policies. The interview also serves as a check on the ability of the personnel department to select desirable workers and place them in the correct positions. In an effort to lower unnecessary labor turn-

[3] *Monthly Labor Review*, issued by Department of Labor, Washington, D. C.

LeTOURNEAU EXIT INTERVIEW FORM Date________

Employee's Name____________________ Clock No.________

Occupation____________ Foreman____________ Dept.________

I. Experience:

Date Began________ Starting Rate Per Hr.______ Present Rate per Hr.______ Per Week______

Starting Job____________ Present Job____________

What advancement has he had?____________

Has he worked on standards?________ Average weekly index?________

What seniority is he losing by leaving here?____________

II. Separation:

Does he agree with "Reason for Leaving" shown on Stop Card?________

If not, what is his statement?____________

Has he seen foreman's recommendation for reemployment?________

What do you feel is his general attitude? Hostile______ Vengeful______

Unfair treatment______ Reasonable______ Appreciative______ Favorable______

Has this interview improved his attitude?________

Did he mention unemployment compensation?________

Was information given him on unempl. comp.?________

Has he had a bad accident here?______ When?______ What?______

Is there an unsettled compensation case in his name?________

III. Opinions:

Would he advise his friends to work here?______ Why?______

What does he think of the future we offer?________

Would he want to work here again?______ Same Dept?______ Same Job?______

What does he think of our: First Aid Department?________

Personnel Department?________

Attitude toward our employees?________

What suggestions can he make to improve this Company? --

On working conditions?________

On wage rates and pay?________

On hours of work?________

On Supervision?________

On Training?________

On Promotions?________

IV. Where is his new job?________ What?________

When to start?________ What rate per hour?______ Hours per week______

What opportunities are there?________

If he has no job would he like our help in getting one?________

Does he realize the difficulties of getting another job?________

Figure 99. Form Used in Interviewing Employees Who Leave

over, to eliminate causes for quitting, and to foster a friendly ex-employee and public attitude toward the company, this practice has proved of real value. It is not unusual at such a time to find real and imaginary grievances expressed against the company. Hence the interviewer must possess considerable tact in order to conduct a successful investigation and promote a friendly feeling. Figure 99 shows the first page of the form used by R. G. LeTourneau, Inc., in reporting the results of such interviews.

ECONOMIC SECURITY

Under this heading many companies engage in activities which are designed to supplement or stabilize the employees' income. The purpose is largely the same as that expressed in social security legislation, and in point of time economic security plans were in force in most progressive companies many years prior to the passage of our social security acts. Industry has recognized its obligation to aid the economic status of its employees in ways that go beyond the mere payment of a periodic wage. It has also recognized its obligation to employ an equitable proportion of various age groups, although often no definite policy is pursued along this line.

Age of Workers.—Not many workers under 17 years of age are employed in industry. In some cases the minimum hiring age is 18 or 20 years. A lack of effectiveness due to immaturity, minimum wage rates, and liability to accidents are causes. For a time there seemed to be discrimination against workers over 40 years of age. They did not fit into pension and retirement plans, and were probably less productive in advancing years in some occupations. This is no longer generally true, however.

"The increasingly wider use of labor-sparing machinery in steel mills has greatly lightened the toil required in steel operations, and this has made possible the employment of a larger proportion of older men." [4] This is typical of the situation throughout industry. The use of more complex and highly perfected machines has placed greater emphasis upon the value of experience, judgment and dependability. The employable males in the United States over 40 years of age are about 42.5% of the total. In the steel industry, which is typical of many others, 40% of its employees are 41 years of age or over.

Life and Accident Insurance.—Four types of group insurance policies are offered: namely, (1) life insurance, (2) accident and health

[4] Executives' Service Bulletin, Metropolitan Life Insurance Company.

insurance, (3) accidental death and dismemberment insurance, and (4) group annuities and pensions. Group insurance starts when earning power stops. Policies are written to cover not less than fifty employees and, when the employees contribute, the law requires that at least 75% of the employees to whom the insurance is offered be insured. If employees are actively employed when they become eligible no medical examinations are required.[5] This feature enables about 30% of those covered to secure protection not otherwise obtainable for physical reasons, age, or cost, and increases the value of the average worker's estate about 150 per cent. When two or more kinds of group insurance are to be written covering the same group, they may be combined into one "package," or blanket policy.

In contributory plans the employee contributes from 50% to 75% of the premiums. The gross cost for group life insurance is ordinarily less than 1% of payroll, and under the contributory plan the cost to the employer is about ¼ of 1% of the payroll. Some companies pay all the costs of group insurance, but the usual arrangement is for employees to pay a part of the cost as indicated.

The amount of life insurance which any individual may carry under a group policy is fixed by his occupation or classification and may not be more or less than this amount. It may be (1) a fixed sum the same for all employees, (2) varying amounts as determined by wage or occupation groups, and (3) increasing amounts based on length of service. New employees are not insured until they have been on the payroll for a minimum period of three or six months. A minimum of $500 per employee is usually required by the insurance companies. $1,000 of insurance may be provided for those earning less than $1,500 a year; $2,000 for those earning up to $2,500; and so to a maximum of $10,000. Length of service plans usually begin with $1,000 of insurance on a contributory basis after three months of service, with later increases paid for by the employer. These might amount to increments of $200 per year until a maximum is reached, as $3,000 after ten years.

Insurance protection is continued during layoffs, leave of absence or physical disability, provided the employer continues premium payments. If an employee leaves the company he may obtain individual insurance in the same amount without a medical examination. The premium will be based upon his age and class of risk at the time.

Group accident and health insurance pays weekly benefits for temporary or permanent disability resulting from sickness or from non-

[5] Under a plan where the employees contribute part of the cost of group insurance, those who do not elect the plan within three months of the time they are eligible must pass a physical examination. This provision is valuable in stimulating immediate acceptance by all eligible.

occupational accidents.[6] Plans vary, but the usual policy provides a waiting period of seven days, and a benefit period of 13 or 26 weeks. Benefits for sickness are limited to the maximum indemnity paying period in any twelve months in the case of employees over 60 years of age. An example of the plan is as follows:

Weekly Earnings	Amount of Life Insurance	Accident and Sickness Benefit	Employee's Contribution
Less than $25	$1,500	$10 weekly	$ .35 weekly
$25 to $40	2,000	15 "	.50 "
$40 and over	2,500	20 "	.65 "

The cost of group accident and health insurance varies with the risk, but will amount to from $10 to $12 a year for each $10 weekly benefit.

Group accidental death and dismemberment insurance is issued only with group life or group health and accident insurance. It provides for benefits in event of accidental death or dismemberment resulting from occupational or nonoccupational accidents, or the latter only as desired. For full coverage, the cost varies with the risk from $1.17 to $5.85 per $1,000. When nonoccupational accidents only are included, the rate is $1.17 per $1,000 for all classes.

Annuities and Pensions.—Group annuities and pension plans provide a means for assuring employees an adequate retirement income. Government pension plans will probably never provide for more than the very minimum of needs. Most company plans provide for monthly retirement income of 1% to 2% of the individual's average earnings multiplied by the number of his years of service. The normal retirement age for men is usually 65 years, and for women, 60 years, but this may be varied and to a certain extent be optional with the employee.

Large companies may elect to finance their own pension plans, but the trend is in favor of insurance company financing. In the past unsound financing has caused many pension plans to fail. Insurance companies enjoy greater stability than individual commercial enterprises, and offer a guaranty of performance which the latter with their changing policies and varying prosperity cannot assure.

The educational work carried on among policyholders of group insurance by the insurance companies is likely to raise health standards and eliminate accidents sufficiently to justify its cost, aside from the cash benefits paid. Visiting nurse service is maintained in several thousand

[6] Compensation insurance carried under other policies cares for accidents on the job. This kind of insurance is required by law in most states.

Type of Group Insurance	SURGICAL BENEFITS	HOSPITAL INDEMNITY	ACCIDENT AND SICKNESS	ACCIDENTAL DEATH AND DISMEMBERMENT	LIFE
Coverage Provided	Reimbursement for specified operations (while "In-patient" in hospital) resulting from non-occupational accident or sickness	Daily Benefit during hospital confinement due to non-occupational accident or sickness	Weekly indemnity for disability from non-occupational accident or sickness	Payment of full Principal Sum for accidental loss of life, limbs or sight	Payment for loss of life from any cause
Amounts	$2.50 to $150.00 for specified operations in accordance with a schedule	$2.00 to $6.00 daily, depending upon plan adopted	$5.00 to $40.00 weekly, depending upon plan adopted	$500.-$3,000. depending upon plan adopted (higher if with group life)	$500.-$20,000. depending upon plan adopted (permissible maximum depends on number insured and volume)
Rates	35¢ monthly for schedule with $150. maximum	15¢ monthly per $1.00 for 31 day plan; 16.7¢ for 70 day plan	66¢ monthly per $10.00; plan providing 7 days out for sickness, 13 weeks limit	10¢ monthly per $1,000. non-occupational cover	Average monthly premium per $1,000. usually approximates 80¢
Rate Qualifications	Where race or sex extra is indicated, rates are slightly higher	Where race, sex, or industry extra is indicated, rates are slightly higher	Where race, sex, or industry extra is indicated, rates are slightly higher	Rates for 24 hour cover range from 10¢ to 50¢ monthly depending on industry	Cost depends on ages of employees actually insured and may be more or less than 80¢ per $1,000.
Maximum Employee Contribution	Entire cost	Entire cost (except in Mass. and Iowa)	Entire cost (except in Mass. and Iowa)	Entire Cost (except in Iowa)	60¢ monthly per $1,000. if T rate applies
How Written	In conjunction with either A. & S. or hospital indemnity	On employees of a common employer	On employees of a common employer	In conjunction with either life, A. & S. or hospital indemnity	On employees of a common employer
Minimum Number of Employees	50	50	25 (50 in Iowa)	25	50
Age Limits	70 and over excluded	70 and over excluded	70 and over excluded	70 and over excluded (unless in conjunction with life alone)	None
Medical Examinations	None	None	None	None	None
Special Features	Provides one-half benefits for operations (1) on hospital "out-patients (2) elsewhere than in a hospital	Reimbursement for certain hospital charges up to 5 times the daily benefit	Up to 6 weeks benefits payable for pregnancy, including childbirth or miscarriage	Provides payment of ½ Principal Sum for loss of one limb or sight of one eye	Insurance continues for 31 days after employment terminates during which period conversion is permitted

Figure 100. A Summary Analysis of the Main Features of Modern Plans of Group Insurance

industrial communities. From information furnished by insurance companies it is estimated that group life insurance policies in effect in 1941 protect more than 15 million employees, and have an aggregate value of approximately 18½ billion dollars. To this must be added the protection afforded by other types of group insurance to several millions of employees.

Summary Analysis of Insurance Plans.—Figure 100 gives a summary analysis of the main features of modern plans of group insurance.[7]

Stabilization of Employment.—A steady job is essential to economic security. Union agreements in several trades make provision for a minimum number of weeks of work, in some instances 40 weeks, with at least part pay for idle time during this period. Most employers now realize the need for continuous employment in securing low cost production. All industries are endeavoring to avoid layoffs. This is accomplished by regularizing production schedules, and by varying the work hours during peak and slack periods. Some firms definitely provide annual employment; others guarantee a minimum pay check of 60% of the weekly wage. In the latter cases the workers repay any unearned amounts from later earnings in excess of this amount. If the worker leaves, and it has not been possible to repay unearned wages within a given period, the sum is charged off.

In the automobile industry efforts to stabilize employment by early introduction of new models and advance building of sub-assemblies brought the following results.

1. Stabilization of aggregate employment evidenced by:
   (a) Reduction in range of fluctuation from 103% to 41%.
   (b) Variation within a range of less than 9% for nine months.
   (c) 30% to 50% reductions in labor turnover rates.

2. Benefits to the individual workers:
   (a) Increase in steady jobs in two years from 51% to 69% of average number employed.
   (b) Winter work for 150,000 men, otherwise temporarily unemployed.
   (c) A $469 increase in the average income of all individual workers.
   (d) Increase in average income of steadily employed workers of $173.

[7] From data supplied by the Travelers Insurance Company.

(e) Higher annual earnings for typical seasonal workers in auto factories than the average for continuously employed workers in most other manufacturing industries.

Variations in the normal demand for products are caused by more or less periodic major and minor business depressions and seasonal changes. The demand may be stabilized to an extent by simplification efforts, and the choice of production items which are standard at all seasons, or seasonal demands, which come at different periods. For example, a firm which imported and packed dates was accustomed to hiring 1,100 extra workers for four months a year to supplement the regular staff of 200. The company's chemists experimented with keeping dates in cold storage before and after packing, which enabled them to prolong the packing period. Then by adding shredded cocoanut, canned figs, and sliced citron as side lines, regular employment was provided to the profit of all concerned.

In addition to varying the length of the working day and working week, vacations may be scheduled for dull periods. The difference in production time of a 40-hour week and a 50-hour week is 20%. Decreases in output below the normal are not often greater than this. Shifting men from one employment to another also aids in maintaining regularity of employment. Where goods can be produced ahead for stock, reservoirs of finished goods act as a buffer between demand and rates of production.

Unemployment Wages.—Unemployment compensation for workers is provided for by law. In some states the funds which accrue in the state treasury from taxes on payrolls are credited to separate employer accounts. This is known as the American plan. In other states the tax contributions are pooled in a common fund. This is known as the European plan. Under the American plan when the accumulation in an employer's reserve account amounts to a stated amount per employee his contributions are reduced; if a specified larger amount, they are suspended. The cost of unemployment wages to an enterpriser is directly proportional to his unemployment. Under the European plan, the employer who creates a large amount of unemployment pays at no higher rate than does the one who has stabilized his employment. State laws vary considerably, but that of Illinois is indicative of the cost and benefits of this type of legislation.

For any year an employer's contributions (taxes) may be raised to as high as 3.6% of his payroll or lowered to as low as nothing—depending

upon the balance shown in his individual merit rating account. Employees who are eligible and qualified may receive maximum benefits in any one year of $520. The Act provides for a weekly benefit of 5% of the worker's highest quarterly earnings during the preceding calendar year (but not over $20 nor less than $10 per week) for a maximum of 26 weeks. The number of benefit payments depends upon the weeks of employment, and the amount upon the wages paid. Eligibility for benefits involves ability and availability for work, and a one-week waiting period. The law applies to all firms employing six or more individuals.

Thrift and Savings Plans.—As an encouragement to employees to help themselves, thrift and savings plans are effective. Christmas and vacation savings clubs are popular. Arrangements are made for deducting a certain amount from the employee's pay each week and placing it to his credit with the company or a local bank. An attractive rate of interest may be offered to encourage saving, or bonuses awarded. Withdrawals may be made at any time.

Money in the pocket is easy to spend, but a dollar or two a week deducted from wages is not missed. Cash in savings funds will provide for emergencies and incidentals for which workers without savings accounts find themselves unprepared. They foster the saving habit, make possible the initial payment on a home, shares of the company's stock, or something else desired.

Credit Unions.—A credit union is an organization of persons having a common interest, to promote thrift and to establish a source of credit for themselves by creating a safe, convenient, and remunerative joint savings institution. Its basic principle is cooperation and mutual aid. They are organized under a state or Federal charter. A credit union provides a savings plan, with the funds available for loans to members at lower rates than otherwise available, yet permitting attractive dividends upon invested funds.

The interest rates of regular finance companies amount to from 36% to 42% a year in many states. The credit union with its selected memberbership and opportunity to approve loans offers funds to members at one per cent a month on unpaid balances. Loans are made for provident or productive purposes. Those of from $50 to $100 do not require other security than the signature of the applicant.[8] Greater amounts would require signatures of fellow workers or acceptable collateral security. The assets of credit unions are required to be in liquid form, and short

[8] The law in Illinois has recently been amended to permit unsecured loans up to $300. The extent to which this privilege will be utilized, or prove to be good practice is yet to be determined.

time loans only are made, to be repaid in small, monthly installments. Losses are negligible. Loans may be covered by insurance so that in event of the death of the borrower the loan would be repaid by the insurance company.

Employee Stock Ownership.—Ownership of industrial stocks by employees is a decidedly stabilizing influence in industrial affairs. The increase in such ownership is limited only by the ability and willingness of labor to save. Only stock which is listed on the stock exchange, which is marketable at any time, and which is "safer than most bonds" should be purchased by employees. The privilege of purchasing a limited amount of common stock with preferred stock may be offered. In some few instances "employees' prior preferred stock" is issued, which has preference over all other stock as to dividends and assets, with special provision for cumulative and extra dividends.

The amount of stock which an individual may purchase at a time is usually limited to a certain per cent of his earnings, as 10% to 25%. Attempts to pay for more would prove harmful rather than helpful. The prices quoted employees may be less than market prices. Some companies add a further incentive by paying an annual bonus, $5 per share or so, on employee-owned stock, and by paying to the employee the full dividend earned, even though the shares are only partially paid for. Stock ownership by employees constitutes a true partnership in industry, with every incentive for cooperation. Employee stock purchase plans are not as common as they were before the stock market crash in 1929, for the loss in values at that time constituted a hardship on those of moderate means. At present most of such plans are limited to participation by executives, who can afford to take more of a speculative risk.

Home Ownership.—The primary purpose of housing schemes is to provide adequate home and possibly community facilities at reasonable cost for purchase or rental, to bring workers closer to the plant, secure increased cooperation, reduce labor turnover and attract better workers. Home ownerships adds to the pleasure of family life, makes for better and more settled citizens, and hence better employees.

In some lines, such as the mining and steel industries and the textile industry in the South, there has been need for the establishment of towns in order to provide adequate living quarters and satisfactory social conditions for employees. Other companies have cooperated in housing schemes by furthering the development of suburban districts. Still other plans less comprehensive have provided for financial aid and assistance to individuals desiring to purchase or build in established communities.

In planning communities, every effort is made to have them attractive and modern. City planning experts are retained and attention given to boulevards, plazas, parks and playgrounds, the grouping of buildings, the establishment of civic centers, zoning of private property, and the provision for various utility and municipal services.

Even small homes may be of interesting and varied architecture, and built at costs which meet the need of prospective purchasers. They will necessarily need to be sold on easy terms.

The era of the company town is passing. "They grew up in an effort to cut down labor turnover and unrest and to provide social controls necessary for the stability of industry and the good of the workers. Some were well and honestly managed, providing many educational and recreational services which the workers might not have enjoyed otherwise. Others were bad in every way with wretched housing and exorbitant prices at the company store. . . . There is no substitute for free home ownership." [9] In this era of paved roads and automobiles workers may now live many miles from their place of employment. Education, recreation and entertainment are no longer limited to city areas.

[9] "Company Towns Slowly Vanishing," by Edwin C. Hill in his column, *The Human Side of the News.*

CHAPTER 20

THE PERSONNEL DEPARTMENT—OTHER PERSONNEL RELATIONS

Influence of the Plant Upon the Worker.—Through its educational, health, and recreational activities industry strongly influences the type of life the worker will lead. The education of employees has a dollars and cents value for industry, but the long-term effect upon the culture and ideals of society as a whole is of even greater value. The health and safety departments of the plant also have done a great deal to further the general health standards of contemporary society. Likewise, interest in recreation, athletics, and hobbies has been furthered by industrial support in the form of organizational clubs, athletic teams, and vacations. In noting that the worker justly demands of industry the basis to live a human life we should also note that industry furnishes this basis not only through salaries and pensions but also through the encouragement of a multitude of interests, through concern with the worker's health and life, and through the recreational facilities which it makes available. The plant environment is in many cases superior to the social environment of the workers, and as such it provides an essential standard for social achievement.

EDUCATION AND TRAINING

Democracy should provide equal opportunity for all. Opportunity today knocks only where the prerequisite skills and knowledge are already possessed. In order to maintain a democratic culture under these conditions education must be available to all who desire it. Education within industry pays dividends not only to industry but to the worker and to society. It enables industry to train potential executives and specialized personnel. It enables the worker to seize opportunities and to keep his attention fixed upon the future and progress. It makes the social order an open one where class distinctions are not hard and fast; where progress is possible and real.

The industrial education program is usually under the personnel department and is concerned with training for executives, college men, foremen, and apprentices. Specialized job training may be undertaken when experienced workers are difficult to obtain. Courses aimed at the

personal advancement of employees are usually conducted outside the plant either with or without company aid, but in all cases with company encouragement.

Executive Education.—Formalized study for executives is seldom desirable because of varied individual aims and needs, yet this group deserves attention. General administrative intelligence is rarer than professional or technical talent, for sufficient breadth of understanding, constructive intelligence with regard to company affairs, and ability to cooperate effectively are not ordinarily gained from performance of specialized tasks.

Home study courses are good. Better, where available, are the off-campus classes being established by colleges and universities in some communities. Courses are offered in business and industrial organization and operation, labor management, accounting, and allied subjects. Junior executives and others interested who are qualified thus have specialized college training brought to them. Trade and technical magazines are informative with regard to trade and economic conditions. *Factory Management and Maintenance* and similar magazines make available for study the policies and practices of many progressive concerns. The value of such material cannot be overestimated. Books dealing with the technique of every phase of business may be obtained in libraries and from publishers. General reading of current literature is essential for an appreciation of social and world conditions, and of the best thought with regard to them. Mental contact with people of widely different interests is truly educational.

Training College Men.—The introduction of college men into business as potential executive material requires training which will adapt them to the needs of particular companies. As preliminary training, experience in various fundamental operating departments is desirable. This may then be followed by specialization in work leading to positions in manufacturing, selling, advertising, accounting and finance, research and statistics, or personnel relations. In this way each student gains a first-hand knowledge of production, understanding of the technique of management, appreciation of fundamental principles in operation, and greater proficiency in a selected phase of management. Above all, he gets perspective.

Training programs are sometimes formally organized, with study assignments, lectures, and class sessions in addition to work requirements. More often, individuals are fitted into the organization, transferred from one department to another, and given training in the various phases of work.

The Education of Foremen.—Foremen occupy an important position in the managerial organization of the company. They are selected from individuals who show a capacity for leadership, and possess the trade or craft skill necessary to direct the work of a group or section. They should have a knowledge of the company, its products, their uses, and the duties and responsibilities of foremanship. Subjects for study are the company's history, its organization, policies, sales programs, factors in production costs, attitude toward labor, purpose and value of inspection, methods of cost reduction, the technique of shop management, the art of handling men, and the like. Knowledge of this kind explains to the foreman the *why* of what he and others are doing, makes him a better and more loyal assistant, able to interpret the company and its policies to his men.

The more immediate problems confronting the foreman should be taken up first. These will include man management, rating workers for promotion, shop conditions, the basis for setting rates, motion and time study, wage scales, production control, and the purpose and value of reports. Intelligence in these particulars finds ready application and leads to interest in more general topics.

Formal education for foremen may be by means of (1) lectures, (2) the use of textbooks, or (3) the conference or discussion method. The immediate success of any plan is dependent upon appreciation of the use value of the subject matter.

The lecture method is used successfully for getting across ideas and general information, and for inspirational talks. Good textbooks possess the merit of presenting subject-matter in tangible, permanent form, which is well organized, thorough, and comprehensive. Yet for foremen as for other students something additional is needed, and this is a competent, educational leader. Group discussions serve to interpret the text, translate it into use terms, and add interest. The expression of conflicting ideas and opinions does much to stimulate thought, develop reasoning powers, and add to the confidence of those participating.

Texts chosen should be simply written, plain type used, and well illustrated. Statement of principle should be followed with examples, for shop men reason more readily from experience than from principles. That this is good educational procedure is suggested by Carlyle's statement: "He is most original who adapts from the greatest number of sources." The difficulty with textbooks is that they are necessarily general, and less effective than if written for the particular industry or plant where they are used. Much of the benefit of textbook courses comes from organized discussion at frequent meetings. Some of the larger concerns prepare mimeographed text material covering plant practices, and this is doubly interesting and effective.

The conference method suggests group meetings of foremen, preferably about a table, for the consideration of common problems and for instruction. The topics to be considered should be known in advance, so that each individual may be prepared to present his experience and ideas or make known his difficulties. To be effective, conferences require a leader skilled in the direction and control of discussion. The use of some text material, and occasional talks or lectures are usually advisable. At the close of each meeting the leader will do well to summarize the ideas brought out, and suggest their application. In this way each participant will carry away tangible, usable ideas which he has helped to crystallize.

There is a considerable magazine and book literature of value to foremen. Classes are also organized and conducted by specialists in the field. This movement reaches the small shops and isolated factories through the formation of plant and city foremen's clubs. The larger concerns profitably work out courses of their own. In the Westinghouse Electric and Manufacturing Company, men taking foreman training may work in the time study, scheduling and planning, and cost departments. From this they learn not only the mechanics of the game, but what is more important, the spirit of the game. They see the need of leadership, techniques of control, of fair play and a cooperative spirit.

The cost of foreman education is nothing compared to the cost of the lack of it.

Apprentice Training and Job Training.—Apprentice training is enjoying a well-merited revival. For a number of years the demand for machine operators made it possible for young men with little experience to earn abnormally high wages. Under these conditions few were willing to serve long periods of apprenticeship at nominal wages. During the depression years apprentice training was discontinued in many plants. With a return to normal, the constant and growing demand for skilled tool makers, machinists, and machine builders asserted itself. Capable craftsmen for these jobs are available only after several years intensive training of good men, however, and this must be provided.

Many of the larger companies have apprentice training schools which offer responsible young men with high school training an opportunity to spend three or four years learning a trade, receiving an increasing although nominal wage while doing so. Firms in some industries contribute to trade schools which serve the industry, such as the textile schools in New England. In Milwaukee and other industrial cities vocational schools are established which set up related training courses for the various occupations in which apprenticeships exist, and through

advisory committees determine what should be covered in the curriculums offered. There are over forty occupations in which such apprenticeship arrangements are offered in the Milwaukee area. In this way even small firms may train apprentices effectively, and thus the burden of such training is not carried solely by the big concerns. The scheme has proved exceedingly popular and attracts large numbers of high-grade young men into industrial work. The development of this plan may well result in a national movement, effective not only in training apprentices, but in preaching the dignity and value of industrial education and work.

Vestibule Schools.—Vestibule schools may be used to train workers for a particular job or aid in apprentice instruction. This training is carried on apart from production in a special part of the plant or in a separate shop, and is usually of brief duration. Some marketable output is obtained, but much spoiled work is to be expected. An objection is that the expense of installing equipment and salaries of instructors necessarily entails a considerable initial cost and high overhead. With an uneven demand for workers difficulty is experienced in utilizing to advantage the various kinds of equipment. The vestibule school idea is most useful for quick training in a week or two for small assemblies. It may be entirely impractical for many jobs, as on heavy lathes, planing mills, and the like. Workers trained in a vestibule school to operate a particular machine may wish later to return and qualify for other tasks. Inducements should be offered for doing this by paying part of the worker's wages while in training, and by increasing his hourly rate when he returns to the shop.

Training Under Actual Conditions of Production.—Training in the shop under actual working conditions is often more economical and more effective than the vestibule school idea. Beginners are placed under foremen who may give time to this work, or under assistants who act as instructors. The latter individuals may be delegated from the central training division for the purpose, or may be assistant foremen, or skilled workmen who have some ability and willingness to impart their trade knowledge to others. In the latter case extra compensation is usually given for this service.

If training is being given for a particular job, the period of preparation will be short. If more comprehensive training is offered, its administration should be centralized in the personnel department, and a constant check made to assure that apprentices are maintaining interest, making progress, and getting a variety of experience. Without executive interest shop foremen may keep beginners on a narrow range of work, ignoring

the aim and expectation of apprentices to become proficient in all phases of the trade.

Apprentice training may also be combined with part-time continuation of school work when the apprentices have not received the required amount of public education.

Education of a More General Nature.—In the larger companies many courses of study are open to employees. These are intended to aid the worker in securing knowledge of business principles and an understanding of the business in which the company is engaged, and in attaining proficiency in the performance of particular tasks. Advantage may also be taken of courses in local institutions, part or all of the expense of tuition of courses completed being refunded by the company as a means of encouraging ambitious employees to profit by educational advantages.

Correspondence school courses of worth are available. Not many persons, however, have the ability, courage, and persistence necessary to follow these courses through to completion. Isolation, adverse study conditions and lack of preparation and fitness for the work undertaken cause many failures. Those with sufficient basic training find these courses admirable as an avenue leading to proficiency in technical or professional courses. Extension correspondence courses and the off campus classes conducted by colleges and universities are stimulating and worthwhile.

HEALTH AND SAFETY

The direct influence of the industrial health and safety programs upon the standard of living and the average length of life has been great. The safety movement, beginning with an attempt to protect the worker from accidents, has expanded into a plan to protect the worker from all industrial hazards and to insure his good health on the job. Health on the job naturally means health off .the job, and the benefit is real both to society and to the worker. Industrial health programs carried out as they are under the supervision of qualified medical authorities have familiarized people with up-to-date medical procedure, and shown them how much they can expect from medical care. It is no exaggeration to say that the general standards of health and the extent to which medical care pervades society have been increased by industrial health programs.

The Beginning of Safety Work.—The safety movement had its beginning in 1892 at the Joliet Works of the United States Steel Corporation. A "safety inspector" was appointed in 1893, and in 1906 the

movement was extended to other plants of the corporation. A growing interest throughout industry in accident prevention was crystallized in the organization of the National Safety Council in 1913.

Accidents a Social and Economic Waste.—For many years workers and managers failed to cooperate effectively in accident prevention efforts. Workmen were careless, even reckless, taking chances needlessly. Superintendents and foremen condoned practices and working conditions which resulted in many injuries. To the human suffering was added the economic hardship imposed upon the families of those injured. Public opinion, legislation, and a growing realization of the cost of accidents in men and money were influencing factors too strong to be resisted. Today, safety is a primary consideration in all industrial activities.

Progress in Making Jobs Safe.—The records of the National Safety Council show that within a twelve-year period the frequency rate (disabling injuries per million man-hours of exposure) of accidents was reduced 68%, and the severity rate (days lost per 1,000 man-hours worked [1]), 45%. Some outstanding accomplishments in individual plants are as follows:

The Western Clock Company, LaSalle, Illinois, operated 11,114,600 man-hours without a lost time accident; [2] E. I. du Pont de Nemours & Company, Old Hickory, Tennessee, 6,116,634 man-hours; United Shoe Machinery Corporation, Beverly, Massachusetts, 8,472,248 man-hours; and the Remington Typewriter Company, Syracuse, New York, 6,145,514 man-hours. The Western Electric Company, Hawthorne Plant, Chicago, decreased its accident rate 95% in ten years.

Planning for Safety.—Safe buildings and environment are a necessary first step; then come machines and equipment designed for safety, and mechanical safeguards. Lighting, air conditioning, and plant housekeeping are important considerations.

The Human Element in Safety.—Safe workmen are those physically fit, mentally alert, trained, educated, and cooperative in safe ways of working. A safe plant and safe workmen are a result of real management interest not only among supervisors and subordinate executives,

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[1] This rate includes arbitrary charges for permanent disabilities and deaths, in accordance with a standard scale.

[2] Lost time accidents are those where time is lost other than on the day or shift on which the injury occurred.

but of the chief executive. The education and training of workers in safety is a task which is never finished. Experience indicates clearly that when efforts are relaxed, accidents increase immediately.

Youthful workers and those inexperienced in the work being done are especially likely to suffer accidents. (See Figure 101.) The beginner is awkward in work habits and the work situation is likely to provoke mental confusion. An older worker on a new job or shifted to a new department will to a lesser extent have difficulty in adjusting himself, but may be injured while doing so. The exuberance of youth is reflected

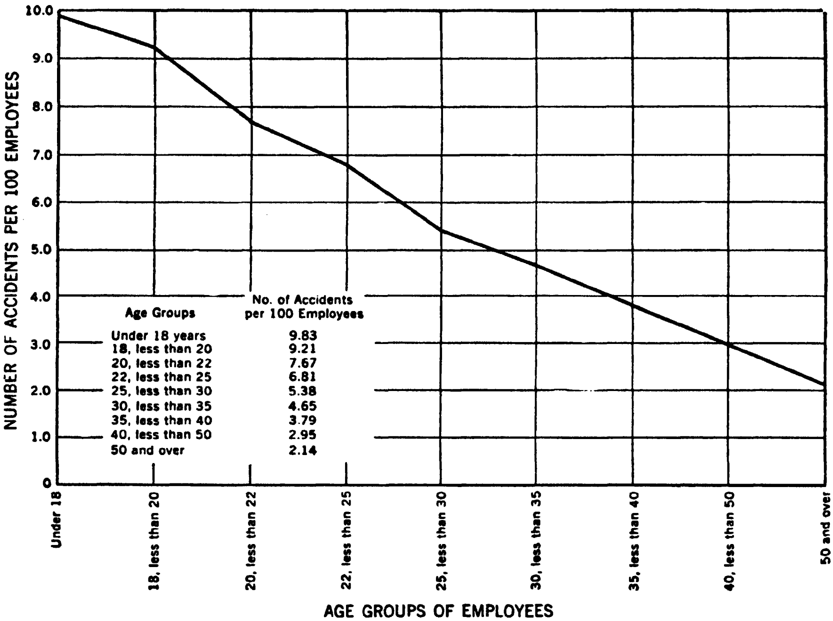
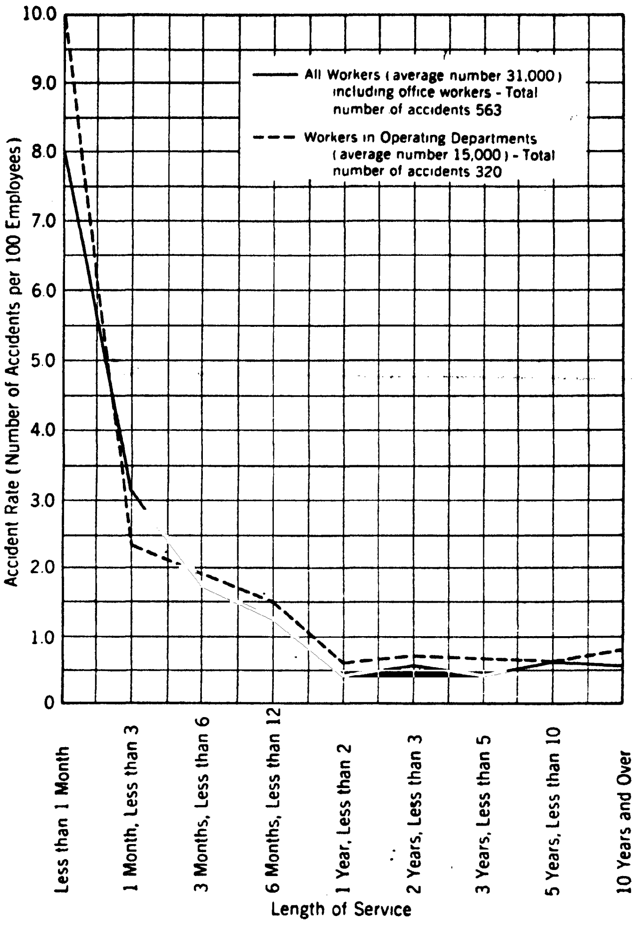


Figure 101. Distribution of All Accidents by Age Groups

(Data cover 67,344 accidents to an average of 24,339 employees over a 4-year period)

in pranks, inattention to the task at hand, and a lack of care. Older workers become familiar with common hazards, and may tend to disregard safety practices. Figure 102 shows the favorable influence of age and experience upon the accident rate.

Work for women in industry is less hazardous. The work is light, men porters do the lifting and carrying, and less danger is involved in attending or operating machines. Fewer accidents occur within this group.



ACCIDENT SUMMARY—ALL WORKERS	
Length of Service	Number of Accidents
Less than 1 month	52
1 month, less than 3	80
3 months, less than 6	75
6 months, less than 12	100
1 year, less than 2	51
2 years, less than 3	26
3 years, less than 5	23
5 years, less than 10	90
10 years and over	66
Total	563

ACCIDENT SUMMARY—OPERATING DEPARTMENT	
Length of Service	Number of Accidents
Less than 1 month	27
1 month, less than 3	30
3 months, less than 6	42
6 months, less than 12	68
1 year, less than 2	36
2 years, less than 3	18
3 years, less than 5	19
5 years, less than 10	43
10 years and over	37
Total	320

Note: Accidents are classified as Lost Time Accidents if the injured employee loses a full day or more from work after the day on which the accident occurred.

Figure 102. Distribution of Lost Time Accidents by Length of Service

Causes and Responsibility for Accidents.—The National Safety Council records disclose the main causes of accidents in industry to be as follows:

Cause	Per Cent of Accidents
Handling objects	25.9
Falls to a different level	8.7
Falls to the same level	9.5
Machinery	12.0
Vehicles	10.9
Using hand tools	7.6
Falling objects	8.7
Stepping on or striking against objects	5.6
Electricity, explosives, heat	3.6
Harmful substances	2.1

In an analysis of a large number of lost time accidents responsibility was placed as follows:

Responsibility	Per Cent
Employee's	38
Carelessness of others	6
Trade risk	18
Supervisory	7
Faulty equipment	4
Poor housekeeping	3
Faulty practices and methods	3
Lack of safeguards	3
Divided responsibility	18

From these data it is apparent that most effort must be directed to educating workers in safe ways of work.

Organization and Education for Safety.—Every person connected with a plant must be made safety conscious and safety minded. The executive management may work through a permanent central safety committee limited in number. This group will meet with the operating superintendent at stated intervals, and reach the rank and file through a plant safety committee made up of representatives from each department, and with a rotating membership. In time a large proportion of the employees may serve on this committee.

Ways of interesting and educating the workers are many and varied. Bulletin boards and posters are generally used. Literature is distributed in pay envelopes; articles are written for the plant magazine, and safety campaigns and contests are held. Constant educational effort is the principal means of reducing accidents.

Why Accidents Occur.—To ascribe accidents to carelessness is in many cases insufficient, and underlying causes should be ascertained.

The *why* of carelessness is the real problem. There is a direct relationship between accident frequency and health. Mental or physical sluggishness from any cause results in accidents. Fatigue may contribute to accidents to some extent. The accident rate increases during the first three hours of the morning period, decreasing the last hour. The trend is similar in the afternoon, excepting the peak is lower than in the morning. The fact that the accident rate for the afternoon period is lower, tends to eliminate industrial fatigue as an important reason.

Safety on the Job.—For a typical industrial group it was found that for each lost time accident in the plant, three such accidents were sustained by members of the group outside. No deaths resulted from plant accidents, but fourteen fatalities resulted from injuries to workmen in accidents outside the plant.

The Cost of Accidents.—Accident insurance covers medical costs, and compensation awards reimburse the worker in part for lost time. Direct costs under favorable conditions may approximate $1.75 to $2 or more per 1,000 labor hours. The employer finds, however, that the indirect costs of accidents not covered by insurance exceed the direct, insurable costs from four to eight times. Accidents within the plant result in absences from work of about one-half day per employee, per year. The cost of accidents includes: [3]

1. Time lost by injured employee.
2. Time lost by other employees through curiosity, sympathy, or aid to injured employee.
3. Time lost by foreman or other executives in giving aid, investigating cause, selecting, training, and breaking in a new employee, preparing insurance and state reports, attending hearings.
4. Damage to machines, tools, materials.
5. Interference with production, failure to fill orders on time.
6. Payments by employers under employee benefit systems.
7. Wages continued in full or in part, although injured employee may not earn them because of incapacity.
8. Profit lost on injured employee's productivity.

Health and Physical Fitness.—Illness is the cause of lost time to the extent of about seven days for men workers, and nine days for women workers a year. An almost equal loss is probably sustained due to workers who are indisposed, but remain on the job. These losses can

[3] "The Good Safety Job Can Always Be Done Better," by John Stillwell, *Factory Management and Maintenance*, Vol. 98, No. 2.

be materially reduced by air conditioning and health programs. A New England company estimates an average direct loss due to these causes for each man employed of $60 per year, with an even greater indirect loss to employees and the community of $67 per year. The former figures include cost of replacing men, idleness, and lowered efficiency of returning workers; the latter, loss of wages, reduction in earning capacity, medical expense, public expense, and charity.

Functions of the Plant Medical Department.—The functions of the plant medical department may be outlined as follows:

1. Physical examinations.
   Of prospective employees.
   Of employees returning to work following illness.
   Of employees undertaking new jobs, if there is any question as to their physical fitness.
   Of employees who feel that their health is being injured.
   Periodic re-examination of all employees.
2. First-aid service.
3. Possible home or hospital medical attention.
4. Regular inspection of plant and grounds from a health standpoint.
5. Promotion of health education, and counsel with employees on health problems.
6. Cooperation and influence in community health conditions and standards.

Applicants for work should be passed upon by the medical department before being employed. Those with communicable diseases or serious physical or mental defects can thus be eliminated, and individuals chosen for each job who are physically suited to the work. Re-examinations of all employees, including executives, at regular intervals, call attention to minor pains and aches which may be the danger signals of serious diseases to follow. Attention should be given to tests for sight; hearing and to dental inspections. Where glasses or dental work are required, they should be supplied at cost. Vision is of major importance in many types of work; while dental deficiencies may be the unsuspected cause of physical ailments, which, although they permit persons to be on the job, seriously lower vitality.

The First-Aid Department.—A first-aid department is maintained to care for accidents and health service, and to the extent warranted, nurses, hospital service and medical attention are provided. All injuries, no matter how slight, should be cared for to prevent the grave dangers of

infection, suffering, loss of time, and possible permanent disability which may follow. Fortunately the working public is showing a greater appreciation of industrial medical service and its purpose, due to the educational advertising of the Metropolitan Life Insurance Company and others, and to satisfactory experience with results. Certainly employees should appreciate the opportunity to secure medical service at the plant when suffering with headaches, colds, or other physical troubles. Foremen should urge employees to avail themselves of this service, for experience proves that employees who do not do so are responsible for from 70% to 80% of time lost on account of sickness. A bulletin of the United States Public Health Service tells of a plant with medical service which has an 18% better attendance record than the plants without such service. The difference was attributed to less sickness. At the present time the general practice is not to extend health service into the homes.

Plant Sanitation.—The sanitary condition of the plant should be subject to the approval of the plant physician, and his interest and influence should extend into the community in all matters tending to eradicate the causes of disease and promote community health. Plant sanitation is a matter of administrative policy and effort, coupled with the worker's cooperation. The latter is obtainable only at considerable educational effort in developing an appreciation of sanitation in the minds of workers. Clean, light, well-ventilated, orderly plants with well-kept and pleasant grounds are an asset. Employees like to work in them, accidents are reduced, lost time cut down, and morale improved. Sanitary practices need to be made natural practices, and in this effort the influence and example of foremen is of prime importance.

Cost of Medical Service.—Small plants may utilize the part-time service of industrial physicians, or possibly provide a joint medical department for the benefit of participating neighborhood plants.

The cost of medical service for employees varies from an average of $7.53 for smaller plants with 500 or less workers, to $4.30 for plants with 10,000 or more.[4]

Plans for Medical Care.—Plans for the medical care of employees and their families are operated or fostered by some companies. Community plans for medical care are also increasing. With these arrangements the individual may obtain all necessary medical care, hospital service, and nursing aid needed for himself and dependents for a nominal annual

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[4] "Medical Care of Industrial Workers," by the National Industrial Conference Board, Inc., Table 13.

charge. The "Plan for Hospital Care" in Chicago, available to employee groups provides the following services:

1. Twenty-one days of hospital care in a year.
2. Use of operating room.
3. Maternity care.
4. Drugs and dressing.
5. Laboratory services.
6. X-ray examinations.

The plan does not provide for the doctor's bill, or for private nursing service. The cost per subscriber, handled by payroll deduction, is as follows:

For a subscriber alone the fee is....................	$ .80	a month
For a subscriber and one family member the fee is....	1.50	"
For a subscriber and two or more members, regardless of number, the fee is............................	2.00	"

Company plans in smaller communities provide all needed medical, hospital, and nursing service to employes and dependents for a cost in the neighborhood of $36 a year, sometimes less.

The General Motors Corporation provides for hospitalization benefits for employees of three months' service and upward of $4 per day up to 70 days for a single disability, and for benefits of $10 to $150 toward defraying costs of surgical operations. Other hospital services are included. The cost to employees is 75¢ a month. Life, health, and accident insurance is provided for $1.23 a month.

The E. I. du Pont de Nemours & Company has a plan financed entirely by the company. It provides that all wage earners having one year of continuous service will receive full wages during disability from nonoccupational illness or injury for a maximum of three months, less a waiting period of two consecutive working days.

REST AND RECREATION

To a far greater extent than is ordinarily recognized the plant is the basis for social activity. The worker's job affords an opportunity for meeting new people, making new friends, and entering into new activities and interests. This is especially true of large industries, but it applies to the smaller ones as well. The recognition of this fact through the organization of clubs, athletic teams, the publication of a plant periodical, the installation of a cafeteria and a recreation room furthers this tendency and increases employee morale because these activities give to the employee a desired social background to his work.

Plant Publications.—Plant publications are the accepted means of communication between the management and large groups of employees. Filled with personal items, humor, pictures, and announcements of employees' activities, they are read by all with interest. Week by week matters of policy, information about the business, and other informative material may appear, and the ideas and ideals of the company made clear not only to employees, but to their families. This material is likely to be read when the worker is in a friendly frame of mind, to be received without argument, and to leave a lasting impression. The plant magazine is perhaps the greatest single medium which may be used to weld a large force together and develop a unified plant spirit and loyalty.

Restaurant Service.—So great is the importance of good food, served under conditions which permit the worker to eat without hurry, that a

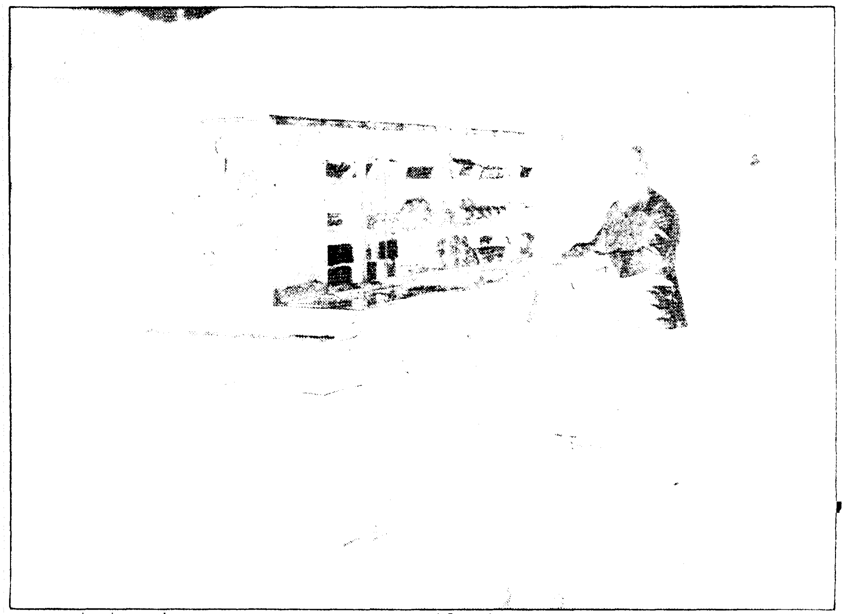

Figure 103. A Company Executive Looks Over One of the Rolling Cafeterias as It Starts on a Round in the Westinghouse Electric and Manufacturing Company Plant

number of business organizations within the Chicago loop district have established private restaurants for employees. Some make no charge for service. Sufficient well-cooked foods of the right kind are often not provided in the worker's home, or in his dinner pail, and eating places of a good kind serving food at low prices may not be handy. For these

reasons the serving of meals to employees often becomes a necessary task, and may be expected to increase production from 5% to 10%. A wide variety of food is not essential, but it must be well-cooked, attractively served, and made available without delay. A well-balanced, hot meal in the middle of the day will do much to keep a worker efficient. He may be encouraged to eat this by serving a regular meal at a flat rate. Cafeteria service is most popular, however. This permits those who bring sandwiches to supplement them with soup, coffee and pie, or other food. Whatever the form of service it is invariably provided at or below cost to encourage maximum use.

Where cooked foods are not provided, milk and coffee and perhaps fruit and sandwiches are very often sold from trucks which go through the plant. The lunch habit in the middle of the morning is not an uncommon one. Many plants think it desirable to have milk, coffee, soft drinks, candy, and sandwiches available at any time for all who are hungry. Lunches ward off fatigue and keep people cheerful.

Employee Recreation.—Rooms for rest and recreation are a necessary part of plant arrangements. They may be merely places where the worker eats his lunch and then enjoys his noon hour, or they may be set apart for reading, study, dancing, movies, dramatic productions, orchestra music or band concerts, games and other enjoyment. The extent and degree of simplicity or luxury of these accommodations will vary greatly. They should be suitable. In the city, employees of small businesses will depend mainly upon facilities made available by the community. In small towns and isolated communities the company may need to make up a lack of community advantages. In the medium-sized town, especially, business interests should cooperate with civic authorities in providing parks and recreation areas. Opportunities for more wholesome and happy living by children contribute to family life.

Plant Conveniences.—Women workers especially appreciate pleasant and comfortable rest rooms, which may have arrangements for cooking, including refrigeration service. For telephone operators and those who alternate work with rest periods, sleeping quarters are supplied.

The morals, morale, and production efficiency of a factory working force may all be improved by intelligent attention to the subject of plant conveniences.

Lockers, Wash Rooms, Etc.—Lockers, toilets, washing and bathing facilities, drinking watei, dressing rooms, and the like need to be adequate, air conditioned, well-lighted, and otherwise suitable and sanitary. Observation of the condition, extent, and location of these facilities in

many plants leads one to think that executives give little thought to such matters. Certainly many fail to appreciate the effect upon the workers of primitive conditions in these respects.

Some plants are properly equipped; but with lack of upkeep toilets, lockers, and shower rooms become so unclean that the workers use them as little as possible, and consequently their utility is destroyed. The attention paid by the gasoline filling stations to the cleanliness of their rest room facilities shows the importance of this detail.

In a single generation we have made the transition from employees with little school training and simple, often primitive living conditions, to a group mostly with high school training and reared in homes with conveniences. They are sensitive to environmental conditions. Plant workers expect to come to work properly dressed in street clothes, and have the opportunity to change into work clothes in the plant locker room. In the evening they should be able to bathe, if the character of the work suggests the need, or wash, don street clothes, and depart invigorated and refreshed.

Cool drinking water should be convenient to all. Fountains or other arrangements should be kept scrupulously clean, and be located in the open where light and air are plentiful.

Athletic Teams.—The urge to play, the stimulation of friendly competition, the appreciation of physical prowess, and our inherent love of outdoor life are shown in the appeal which games and athletic events have for all. Athletics suggests strength, health, vitality, and a lively interest in life. To encourage plant athletics is to foster a wholesome side of man's nature, add interest to daily work for all in the plant, and provide beneficial recreation for many. It is an antidote to radicalism, bad associations, and time spent in unhealthful ways. Athletics brings the play spirit into business and industry.

The usual and more easily arranged games are bowling, volley ball, basketball, tennis, and baseball; but boxing, wrestling, track events, golf, and trapshooting find a place. The lighting of athletic fields at night has brought increased interest and participation in softball and other outdoor sports.

Small concerns will have limited facilities for organized play, and must necessarily depend upon community recreation centers. With larger employee groups and the provision of gymnasiums, grounds, and equipment, departmental competition will develop, and as an outgrowth, company teams which compete with those from other factories or in open tournaments. Annual field and picnic days are big occasions in many organizations.

Vacations for Employees.—The practice of granting vacations with pay to all employees has proved good management policy. The "why" of a vacation, whether for manual or office employees may be summed up as follows: [5]

1. It provides relief from the monotony, strain, and intensity of work, and results in renewed energy and vigor.
2. It has a good effect upon absenteeism; an employee is much less inclined to take a day off now and then if he is assured of a reasonable rest period some time during the year.
3. It has a tendency to reduce labor turnover, especially when the extent of the vacation is based on length of employment.
4. It provides a period for rest and relaxation with freedom from worry about the loss of earnings needed for the family's support.

The length of the vacation period may be the same for all employees, vary with length of service, or be partly dependent upon a satisfactory record of attendance. Arrangements may be made for all workers to take their vacations at the same time, excepting the few necessary in the office or for maintenance work. Other plans call for vacations to be scheduled during the summer months, with a minimum of interference with activities. Employees with a year of service may be granted a vacation of one week; those with longer service, two weeks. Vacations of three and four weeks are sometimes granted to older employees with long and satisfactory service records.

A vacation with pay should not be granted unless the worker will use the time for recreation; neither should the option be given of accepting extra pay in lieu of a vacation. This practice negates the beneficial effects gained from the vacation plan.

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[5] Pamphlet, "The Why of a Vacation," by the Metropolitan Life Insurance Company.

CHAPTER 21

FATIGUE AMONG WORKERS

The Burden of Fatigue on Industry.—The ease with which work is accomplished greatly affects productivity. Tired workers are slow, inaccurate workers, liable to accident. Important, too, is the realization that the best employees avoid jobs which are unduly exhausting or wearisome. It has been the practice in the past to include "fatigue allowances" in production job times. The money value of these allowances when hundreds and sometimes many thousands of workers are employed by a single company amounts to thousands of dollars, and in some cases a million or more annually. Recognition of these facts has led to a study of fatigue causes and an analysis of the economic and social aspects of the subject. In recent years increasing emphasis has been placed upon simplifying work situations and perfecting work arrangements to minimize the physical effort required in doing work.

The progressive firms in business and industry have demonstrated that it is good management to provide excellent working conditions in all respects. Dirt, gloom, and drudgery are no longer acceptable. Workers expect to and do complete a day's work physically and mentally eager for further participation in domestic, social, and citizenship activities. This is as it should be. The emphasis is shifting from the necessity of working to live to the art of living. The elimination of unnecessary fatigue, more attention to the comfort of employees, and the greater utilization of intelligence and skill, make jobs more attractive. Social distinctions between the shop and office disappear; better morale and plant spirit result, and this influence carries over into the community. From many viewpoints it pays to use the employee's back less and his mind more.

Causes of Fatigue.—The productive capacity of the individual is a result of the sum of his activities, both at work and during his leisure hours. Fatigue factors incident to the job include the physical demands made upon the worker, the nervous strain involved, noise, air conditions, monotony, hours of work, illumination, accident hazards, health hazards, and other working conditions. As regards the hours off duty, food, rest and relaxation, physical activity. mental work, emotional stress, worry, and the degree of physical health ordinarily enjoyed should be considered.

Definition of Fatigue.—In business and industry management is interested in the effect of the employee's job upon him as it manifests itself in a diminished quantity and quality of output. For our purpose, then, fatigue may be defined as the diminished capacity for work, resulting from previous work. This is likewise the common understanding and use of the term.

The Physiology of Fatigue.—The human body is made up of mechanisms which take in and give out energy in the process of doing mechanical work. The principal mechanisms are the nervous system, the circulatory system, the respiratory system, the muscular system, and the digestive system. The central nervous system transmits messages over the nerve fibres to the muscles, and thus controls their activity. It sustains fatigue in doing this, although the fatigue sensation may be referred to the muscles. In fact, it is the central nervous system which becomes tired and not the muscles in use doing a particular task, which causes us to slow up or stop work. The body is protected from injury in this way, even though the human will would demand excess exertion. The circulatory and respiratory systems have a reserve capacity sufficient to care for any temporary abnormal loads which may be imposed upon them. As a consequence of exercise or work the lactic acid content in the blood stream increases, and the body gives off more carbon dioxide. Medical opinion, however, seems to indicate the real cause of body fatigue to be as above indicated. Fatigue also has its psychical aspects. The will to work is important. Emotion may cause exhaustion or shock to the nervous system sufficient to preclude the doing of work; or under the excitation of fear or a great desire for accomplishment it may make superhuman effort possible.

Health and Fatigue.—Fatigue stands in relation to disease as both a cause and an effect. A person who is sick experiences fatigue much more quickly than when not suffering bodily impairment; and conversely, disease and physical ailments are sometimes a resultant of fatigue causes. Investigation discloses that "on men of good physique the fatigue of heavy work has, as a rule, but little direct effect on sickness and longevity."[1] The United States Public Health Reports and a study made in New York City hospitals provide information of the extent of various ailments among different classes of patients. The data appear to indicate that the fatigue conditions incident to employment are not a pronounced factor in any one group.[2]

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[1] "The Influence of Fatigue on Health and Longevity," by H. M. Vernon, *The Journal of Industrial Hygiene*, Vol. 3, p. 93.
[2] United States Public Health Reports, Vol. 41, No. 4, p. 113.

Mental Fatigue.—Fatigue occasioned by mental effort is as real and the same as that following physical effort. When the mind works in routine channels, as in thinking about accustomed things, the wear and tear is slight. Original, creative thinking, as accomplished in the design of a new machine or the solution of perplexing problems, exacts a greater toll, which varies with the capability of the person engaged.

Effect of Environment.—Apart from physical and mental effort the environment of the worker is probably the chief factor in producing fatigue effects. In other chapters the influence of light, heat, atmospheric conditions, and comfort of floors has been discussed, and the effects measured, at least approximately. Noise, vibration, insanitary conditions, fear of danger, play important parts. In the main, these are unnatural conditions. A worker in a steel plant, or office adjoining, suffers fatigue as a consequence of his environment without doing any "work." The amount of energy utilized in adapting oneself to surrounding conditions may be an appreciable part of the day's expenditure of energy. Obviously the more that can be conserved for production the better.

Monotony as a Fatigue Cause.—It has been popular to assume that industrial operations are monotonous, or more so than formerly, but study seems to indicate that in general, primitive industry held less of interest for the workers than does production today. Primitive farming as compared with modern farming certainly held little appeal, and industry has progressed further than agriculture in the matter of relief from toil. Both now possess almost infinite scope for the interest of those engaged.

Considering the individual, monotony is scarcely a measurable term. The need for initiative, for activity of mind in connection with the work in hand, so essential to enjoyment of the task by some, is shunned by others. How great is the number who would prefer not to assume responsibility, who seek contentment in doing the simplest repetitive operations, is generally unappreciated. Monotony is not a characteristic of any job, but of the individual's reaction to the task. Social workers who dabble in industrial jobs gain erroneous ideas as to this by formulating judgments based on their own mentalities and idealistic conceptions, rather than upon those of the workers and life itself. The life, mental development, social relationships, and ambitions of the individual determine for him what is monotonous and what is not.

The range of business and industrial activity is constantly widening. With the increasing demand for skilled operatives and subexecutives, there would seem to be a reasonable opportunity for the mentally energetic individual to escape from what is, to him, monotonous work. As

the general social advance in average intelligence takes place, each person tends to progress into a niche which calls for his best efforts. To an extent, at least, monotony and unrest are thus avoided. All work becomes monotonous at times, as does play. Human nature being what it is, we are all more or less dissatisfied. Properly directed, this fact may stimulate progress.

Executives realize that too good a man on a job means unrest because of monotony, and consequent expensive labor turnover. Too little ability, on the other hand, may induce excessive fatigue, which contributes to faulty production. R. I. Rees, of the Bell System, expressed the ideal aim in this matter when he said, "We want our men and women to feel that on the basis of their capacity, training and social background, they are working at jobs which require their best, that will force them to grow and in which they will feel successful." [3]

Mental Attitude of Worker Important.—The state of mind or mental attitude of the employee has considerable to do with the amount of fatigue experienced. If he is at odds with his boss, with his fellow workers, or life itself, he will be more tired at the end of the day. It is usually more tiring to "kill" time than to work at a normal pace, with a normal interest in the job. A person who loses himself in his work seldom complains of fatigue.

A spirit of industrial democracy in a shop, rather than of semi-autocracy, makes for a feeling of mutual friendliness and of contentment. Work is easier and better because of it. A friendly, cooperative attitude prevails, eliminating boredom, and considerable mental and physical weariness.

Mentally irksome and physically wearying toil may be relieved by (1) rotation of tasks, (2) rest periods, (3) sometimes by the introduction of rhythm, (4) by music, and (5) by plans which arouse an interest and individual initiative in the work.

Workers sometimes object to changing occupations during the day, or to periodic rotation of tasks. This practice is restful, however, as it brings into play different sets of muscles or mental faculties. Students appreciate this when they change from the preparation of one study assignment to another, and experience renewed interest and capacity for accomplishment. Rotation of tasks increases usefulness of employees, often adds interest to repetitive work, and qualifies workers for promotion.

Music Alleviates Fatigue Effects.—There are many examples of the use of music to relieve the tedium of work. Concerning an experi-

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[3] "The Selection and Development of Personnel," by R. I. Rees, Proceedings of the Bell System Educational Conference.

ment in this direction, H. E. Miller writes: "Workday music is stimulating, is an offset to monotony, fosters contentment, and brightens the work place. . . . It helps overcome the droop of spirits and energy during the afternoon, offsets the gloom of dull, stormy weather, and is a partial antidote to fatigue." In some work situations music is provided during work periods; in others immediately before work, at rest periods, and at closing time. More and better work, cheerful workers and improved morale are reported. The singing of Negro stevedores and plantation workers is proverbial, and is considered essential to cheerfulness and efficiency. Rhythm introduced by periodic machine noises and operating cycles is valuable in pace-setting, but extremes must be guarded against.

Rest Periods.—It is becoming increasingly the practice to arrange for rest periods of 10 or 15 minutes duration at mid-morning and mid-afternoon. Sometimes shorter periods at more frequent intervals are allowed. The necessity of rest periods to relieve fatigue has not been proven in many cases, but even so, the workers like them, and production will not be decreased because of the shorter work time.

Another way in which workers secure relief is in the doing of incidental work connected with the job, such as obtaining tools, moving material, and arranging work. This usually amounts to from 5 to 10 minutes per hour. Personal time allowances vary from 3 to 5 minutes per hour. One firm which does not have rest periods allows 40 minutes in an 8-hour day in its job time. The worker may utilize this allowance for personal time, rest, or as a way of increasing output, as he chooses.

An allowance of rest time for the operator of a machine is not needed by the machine. This suggests that in time and motion analysis work, operators may be assigned to machines in teams and work in cycles. For instance, a machine requiring two operators may have three assigned to it, permitting each a rest period of 20 minutes per hour. In this way the fatigue effect is eliminated from the production curve.

Arousing interest in the work and developing loyalty to the firm has a far wider value than merely overcoming boredom or monotony, but it does do this also. A worker who thinks of his firm's activities as his own, who is a member of a democracy rather than an autocracy, will have an inward fire which shows itself in initiative, interest, and enthusiasm lacking in the man who responds to direction only. These are foes to fatigue. Morale of this character is gained by education, leadership, and appreciation of men as men, and a willingness to share the fruits of industry with them. Very often it suggests forms of worker participation in management.

Hours of Work.—The accepted length of a working day is very generally 8 hours, although in some industries it is longer; while in a few, shorter. The work week is forty hours. There is advocacy for a 30-hour week in some industries. This is quite different from two decades ago when a 9 to 10-hour day, and a 6-day week were the rule. The gradual shortening of the working day and working week have been due to both social and economic progress. In general, work weeks of 40 to 50 hours are economically sound, production per week increasing rather than decreasing as the number of hours have been reduced. In some industries, such as cotton mills and others, where the influence of machine operations on output is dominant, this is not true.

The last major stronghold of the 12-hour day was in the steel industry. Its abandonment in 1924 was followed by increased dividend payment to stockholders, and reduced tonnage costs. The change brought about a better physical condition of the workers, better mental attitudes, greater outputs, and lower costs.

One way to avoid the fatigue effect of long hours and to decrease the indirect costs of production represented by the investment in plant and equipment has been to utilize successive shifts of workers during the 24-hour period. Some plants operate with two or three shifts, and a few with four shifts working 6 hours each. A food product plant reports success with this latter arrangement, the employees working through the shift with no time out for meals. Some department stores in this country finding that about 90% of sales were made between the hours of 10:30 A.M. and 4:30 P.M. have shortened the working day accordingly, and without wage reductions. The enthusiasm of employees for short work days and work weeks results in increased intensity of effort sufficient to partially offset the shorter work time. It may do so in certain lines where the emphasis is upon manual effort, but in other trades machine time is the governing influence. The social and civic aspects of the work day and work week seem to be adequately cared for with work periods as first suggested above.

Work Arrangements.—The effect of work arrangements upon production time is emphasized in the chapters on motion and time study. For easy accomplishment attention must be given to the design of the work station. One aim of motion and time study is to eliminate fatigue by making work simple and easy to perform. Figure 104 provides an example of specially designed workplaces which save motions, time, and energy. The chairs are of special design to assure proper posture of the workers. The backs may be adjusted and the seats raised or lowered to fit the individual. Foot rests are also provided. Frequently the work

(Courtesy of DoMore Chair Co.)

Figure 104. Example of Work Stations Specially Designed for Ease of Doing Work and Comfort of Workers

station may be designed to permit the worker to vary his posture by either sitting or standing.

Night Shifts and Overtime.—Those who work at night are usually subjected to living conditions adverse to sleep and rest during the day. For persons of the social and financial status of the worker these are difficult to overcome. Night work is also unnatural. However, when night workers can and do secure sufficient sleep and rest, and are capably supervised, the rates of production do not decline for night shifts. Some plants make night work appealing by increasing the rate of pay slightly, enabling the night shift to earn slightly more money working 5 nights a week only, but longer hours. Alternating day and night work at intervals of two weeks or a month is practised, although this means succeeding periods of readjustment to changed living arrangements. Other companies assign workers permanently to definite shifts, permitting transfers, however, as vacancies occur.

Work at night for women workers is objectionable, not only because of the social aspects of the plan, but because the inevitable pressure of domestic duties during other hours cuts in on time which should be spent in rest. Service in hotels or as telephone operators attracts girls and women largely free from domestic responsibilities, and in these situations

sleeping quarters are usually provided. Social legislation is to an increasing extent limiting the hours of work and night employment of women.

Noise.—Noise is often objectionable and it is a fatigue factor. Workplaces which are necessarily noisy, however, do not seem to bring about low output rates, or to prove disagreeable or detrimental to most workers. They seem to disregard the noise. Machine departments are often noisy, but attention to or the operation of machines is not ordinarily difficult or hard, and the fatigue effect sustained with that of the noise added, is not enough to appreciably slow up the workers. It is generally desirable to eliminate vibration and to minimize noise when possible, and perfection of machine design is facilitating this. Workers who find noise objectionable should be transferred to other departments.

Mechanized Operations.—It is economically profitable to utilize straight-line production methods and work conveyors. The resulting trend has been to increase the mechanization of jobs, which raises the question of increased physical and nervous strain on the human element.

In straight-line arrangements the work passes in succession from one worker to the next. In some installations each must do his part promptly in order not to interfere with the flow of work, which is handled mechanically. In planning such work the rate of output is established with this in mind. In other cases units worked upon may be removed from the conveyor if the operator gets behind, until he has an opportunity to "catch up." Dial feed equipment, where the workers are grouped about a revolving table arrangement, is a form of straight-line production, and requires that the work be very evenly divided among the workers and planned from a time standpoint.

Mechanizing operations reduces the physical work involved, but does require speed and manual dexterity. On many mechanized tasks workers find it possible to converse while working. On some jobs the waiting time or idle time while the machine works amounts to from 5 to 20 minutes per hour. These facts suggest the absence of nervous strain. A working day of eight hours will usually be broken by rest periods. In addition, in cases where it is desired to keep equipment in motion, relief operators are provided as needed. If proper attention is given to selection of workers, and they are properly trained and introduced to the work, no fatigue problems should develop.

Lighting and Air Conditioning.—Poor lighting and bad air conditions affect production adversely. The reader should turn to the chapters on these subjects for a further discussion of their effect and what constitutes good management practice.

Accidents.—Mental or physical sluggishness is a major cause of accidents, and may be due to ill health or fatigue. The elimination of fatigue causes decreased accidents. In modern manufacturing plants accidents because of fatigue induced by the work situation are not numerous. They do not increase in number during the afternoon hours, as might be expected if fatigue was a cause. On the other hand, the frequency of accidents during the months of the year is found to correspond closely with the sickness rate.

Reserve Capacity of Workers.—Extensive fatigue studies of workers engaged in production operations in modern plants do not indicate any marked slowing up during the working hours due to fatigue causes. It is evident that many workers are capable of doing more than is normally expected or required as a daily task. Tests for short periods of one or two days show that productivity may be increased an average of 20% or more above the usual. This reserve power enables the worker to overcome the normal fatigue effects of the work situation and to maintain output during the late morning and afternoon periods when otherwise it might be expected to decline.

Daily Production Curves.—A check on the work of four type-setters by Dr. H. M. Vernon, of London, provides interesting and typical data bearing on this subject, as follows: [4]

Output and Errors of Four Type-Setters

Hours	8–9	9–10	10–11	11–12	12–2	2–3	3–4	4–5
Output	21.0	26.0	23.0	21.5	lunch	24.7	20.5	16.0
Errors	4.2	4.6	4.6	7.0		1.4	5.4	7.5

In the morning errors are fewer and the output greater after the workers have "warmed up." Fatigue makes itself felt later. Presented graphically, these data would give a curve with the same characteristics as Figure 105, showing the effect of fatigue on production during the

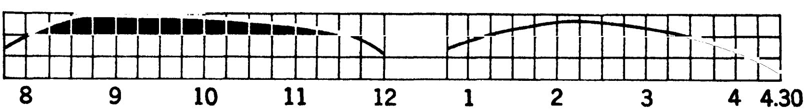


Figure 105. Production Curve Showing Effect of Fatigue During the Hours of the Day

hours of the day. This curve pictures the production record of a drop hammer operator in a forge shop, and includes data taken over a considerable period of time.

[4] Industrial Fatigue and Efficiency, by H. M. Vernon, p. 8.

In the morning an average efficiency of 98% was maintained, and in the afternoon one of 96%. This curve is a typical one, and its characteristics are readily recognized. At the beginning of work a certain length of time is required for the worker to get mind and muscle coordinated and working smoothly. In this instance it was about 45 minutes before greatest efficiency was attained. This beginning period was followed by a period of maximum efficiency, and then by a gradual lessening of the rate of output, production dropping off more sharply as noon approached. The benefit derived from the refreshment and rest incident to the noon hour is evident. The rate of production after lunch is higher than at the beginning of the morning period. The curve rises gradually, but due to increasing fatigue, the maximum production rate of the morning is not reached, and as the afternoon progresses, the cumulative fatigue effect is seen in a much lowered rate of output; the rate at the close of the day being lower than at any other hour.

For tasks requiring greater exercise of mental faculties in combination with manual skill and dexterity, the "warming up" period of the curve would be of greater length; if less, shorter. For light manual operations and some tasks of machine tending, the element of fatigue may not enter as a factor influencing output. (See Figure 106.) In this case the

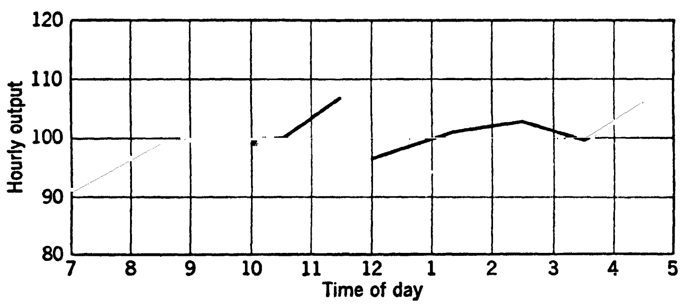


Figure 106. Production Curve Showing Output of Women Working Stamping Presses

(From Industrial Fatigue and Efficiency, by H. M. Vernon, p. 14.)

workers were able to increase output as the hours passed. They were engaged in war work and motivated by a patriotic impulse. The curves are unusual.

Figure 107 shows the production rate for a punch press operation. Also a record is provided of time used in doing incidental work and for personal needs. A characteristic of machine work and mechanized operations is a more even production rate than for manual operations. This

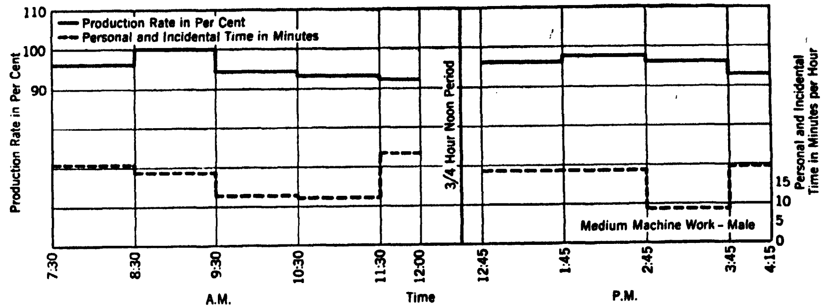


Figure 107. Chart Showing Varying Rates of Production in Connection with Punch Press Operations

(Average performance for 32 productive hours—2 operators, 2 helpers)

job was classified as medium heavy machine work. It was performed by men.

In lines of manufacture where the work is largely or wholly the product of machines, output is dependent almost entirely upon the speed of the machines, and a reduction in hours brings lowered outputs. In other industries fatigue is cumulative to an extent that makes an 8-hour day equally or more profitable than a longer one. This is true when manual work predominates, when the skill, agility, and speed of the worker in operating machines are a sufficient factor, when concentration, or heavy or continuous effort is called for, as in machine shops, shoe plants, woodworking departments, etc. An example will illustrate these statements.

The superintendent of a fine tool manufacturing establishment stated, "We changed from ten to nine hours at our own suggestion and later to eight, . . . as we believe that if a man works conscientiously for a shorter time he can do better work, and that we have a right to expect it. Our records prove the truth of this." [5]

This result is typical of findings in plants in the United States covering various machine and assembly operations. Efficiency over a period of a week is illustrated by the following data, which give the units of output per man, per day. For the first three groups the highest production rate was reached on Wednesday. In performing the heavy work incident to blast furnace operation the relative increase in output is greater for Tuesday and Wednesday than for the other groups, then slowly declines. The bobbin winders continued to gain momentum an additional day as compared with the others, reaching a production peak on Thursday. In

[5] "Hours of Work, Metal Manufacturing Industries," National Industrial Conference Board, Bulletin No. 18, p. 17.

this case an 8-hour work day on Saturday rather than the usual 12-hour day probably was responsible for the increased production rate on that day.

DAILY OUTPUT VARIATIONS *

	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun.
Button sewers	98.1	100.6	101.6	101.1	98.6	....	..
Blast furnace men	96.0	100.0	105.0	103.0	101.0	101.0	94
Weavers	96.0	98.9	102.6	99.3	101.2	102.1	..
Bobbin winders	94.6	96.7	97.6	105.4	96.3	109.4	..

* From Industrial Fatigue and Efficiency, by H. M. Vernon, p. 28.

Effect of Changes in Hours of Work.—When a change is made from a longer work day to a shorter one, an immediate considerable gain in the rate of production is not to be expected. It will follow gradually as a natural consequence in most cases, and more or less unconsciously as far as the worker is concerned, until the increasing rate of output reaches a new normal level. Experience indicates that a period of several weeks, months, or even a year may need to elapse before a new equilibrium is reached. A change to a longer work day will bring an immediate decrease in the output rate. Temporarily this may fluctuate above and below the new normal rate. The operation of effective wage incentive plans will modify these natural tendencies, and generally bring about increased production.

The Employee Off the Job.—It is a common fallacy to ascribe the worker's physical condition and economic status entirely to the conditions imposed upon him by his job. Abnormal and unwise expenditures of energy, and unintelligent living during the remaining hours of the day probably have a greater effect on his well-being. The demands of good management and a considerable amount of social legislation prompt the employer to provide favorable working conditions, reasonable hours of employment, maximum rates of pay, unemployment pay, protection from accidents, and the like. In return the employee should "live up" to his job when away from it, and unquestionably there is a steady advance in better living with industrial and social progress.

Fatigue in Industry Being Eliminated.—Undue fatigue in progressive business and industry is notable for its absence. It is uneconomic, a hindrance to effective employee relations, and objectionable from a social standpoint. Trends in business and industrial practice are furthering its elimination. Fatigue allowances in connection with job times are becoming obsolete as the problem of fatigue is better understood and the causes corrected.

CHAPTER 22

MOTION AND TIME STUDY—JOB STANDARDIZATION AND MOTION STUDY

Definition of Motion and Time Study.—"Motion and time study is the analysis of the methods, of the materials, and of the tools and equipment used, or to be used, in the performance of a piece of work—an analysis carried on with the purpose of (1) finding the most economical way of doing this work; (2) standardizing the methods, materials, tools and equipment; (3) accurately determining the time required by an average worker to do the task; and (4) training the worker in the new method." [1]

Origin and Evolution of the Technique.—In 1881, Frederick W. Taylor originated time study in the machine shop of the Midvale Steel Works at Philadelphia, with the object of determining proper standards for a day's work. His efforts involved study and improvement of the work situation, leading to its standardization, analysis of the task, and setting job times by use of a stop watch. He recognized the importance of the steps preliminary to the stop watch study, but at the time more attention was given by others to this phase of his work because of its recognized value in setting job times. A little later Frank B. and Lillian M. Gilbreth did some notable work in establishing the fundamentals of motion study, where the emphasis was placed upon improving methods. Until recently this phase of the subject was generally neglected by management. Now it is recognized as a principal factor in making work easier and job times shorter. The modern motion picture camera enables tasks to be filmed, and studied in minute detail. Time divisions of 1/2,000th of a minute are possible. Electrical equipments to measure the relative speed of motions involved in doing work give an accuracy to 1/1,000th of a second. Research and experiment using these and other devices add to our knowledge of fundamental information about ways and means of doing work. The information gained enables us to perfect the work situation, and to properly train workers.

The Benefits of Motion and Time Study.—Motion and time study is indispensable to modern manufacturing. Constructive results accrue

[1] Motion and Time Study, by Ralph M. Barnes, p. 1.

as follows: (1) the best production arrangements as to layout, equipment, and surroundings are established and maintained, and improvements stimulated; (2) the best methods, and the skill of the most expert workers are made available to all, increasing average efficiency and earning power; (3) uniformly consistent and correct task times are set, affording an accurate basis for setting wage rates fair to man and management and thus eliminating a prolific cause of industrial unrest; (4) production is increased; (5) quality is improved and made more uniform; (6) waste of time, materials, and human energy is eliminated; (7) production may be scheduled and delivery dates set with assurance;[2] (8) machine and equipment burden rates may be set accurately; and (9) a detail check is provided on the effective functioning of every auxiliary department as previously arranged for—they become truly service departments of the highest order. As a consequence manufacturing costs will be at a minimum, making higher wages and lower prices possible. Motion and time study is the necessary foundation to successful management in manufacturing.

The Early Need for Motion and Time Study.—Frederick W. Taylor's experience as a workman and a foreman made him realize that the worker could greatly increase his output, perhaps two or three times, if the management could *know* the possible output, and would then provide a sufficient incentive for its accomplishment.

In these first days of big workshops the individual lost his identity in the crowd and there was little recognition of varying capabilities; a like wage was paid to all those engaged in doing a certain class of work. "Under this plan the better men gradually but surely slow down their gait to that of the poorest and least efficient. When a naturally energetic man works for a few days beside a lazy one, the logic of the situation is unanswerable: 'Why should I work hard when that lazy fellows gets the same pay that I do and does only half as much work?' "[3] The piece-rate plan had failed to remedy the situation because of the frequency with which rates were cut when workers earned more than employers were willing they should earn. This pictures the general situation which confronted Taylor and other managers and the imperative need for developing a method of control over output which time study as inaugurated by Taylor affords. His efforts were immediately successful.

Taylor's Outline and Definition of "Time Study."—In 1912, Taylor had occasion to outline and define this phase of managerial effort thus:

[2] In laying out work in sequence each man has a certain standard time in which to do his job. The work may thus be handled progressively to succeeding operations and machines and men can be kept uniformly busy and the product completed in minimum time.

[3] Frederick W. Taylor, by F. B. Copley, Vol. I, p. 219.

"Time study" consists of two broad divisions, first, analytical work, and second, constructive work.

The analytical work of time study is as follows:

(a) Divide the work of a man performing any job into simple elementary movements.

(b) Pick out all useless movements and discard them.

(c) Study, one after another, just how each of several skilled workmen makes each elementary movement, and with the aid of a stop watch select the quickest and best method of making each elementary movement known in the trade.

(d) Describe, record and index each elementary movement, with its proper time, so that it can be quickly found.

(e) Study and record the percentage which must be added to the actual working time of a good workman to cover unavoidable delays, interruptions, and minor accidents, etc.

(f) Study and record the percentage which must be added to cover the newness of a good workman to a job, the first few times that he does it. (This percentage is quite large on jobs made up of a large number of different elements composing a long sequence infrequently repeated. This factor grows smaller, however, as the work consists of a smaller number of different elements in a sequence that is more frequently repeated.)

(g) Study and record the percentage of time that must be allowed for rest, and the intervals at which the rest must be taken, in order to offset physical fatigue.

The constructive work of time study is as follows:

(h) Add together into various groups such combinations of elementary movements as are frequently used in the same sequence in the trade, and record and index these groups so that they can be readily found.

(i) From these several records, it is comparatively easy to select the proper series of motions which should be used by a workman in making any particular article, and by summing the times of these movements, and adding proper percentage allowances, to find the proper time for doing almost any class of work.

(j) The analysis of a piece of work into its elements almost always reveals the fact that many of the conditions surrounding and accompanying the work are defective; for instance, that improper tools are used, that the machines used in connection with it need perfecting, that the sanitary conditions are bad, etc. And knowledge so obtained leads frequently to constructive work of a high order, to the standardization of tools and conditions, to the invention of superior methods and machines.[4]

Possibilities of Motion and Time Study.—It will be noted that under (j) job improvement and standardization work is suggested, while

[4] From a paper contributed to the discussion of a committee report entitled, "The Present State of the Art of Industrial Management," American Society of Mechanical Engineers, 1912.

(b) and (c) refer to motion study. The outline suggests the compilation of data for an entire trade, such as that of machinists, for example. When suitably indexed these data would enable a man sitting at a desk to determine accurately the time of doing any operation in the trade. It has not as yet been possible to do this because of the variety of equipment and tools used, differences in methods, and varying conditions existing in different plants. Steps in this direction have been taken, however, in the development of time standards and the preparation of synthetic times from them.

In the past, most efforts have been devoted to making operation time studies—ascertaining the proper time for the doing of an individual task or operation. This is accomplished by observation of the worker at the machine or work station while doing the job.

Divisions of Motion and Time Study.—The task of motion and time study may be divided for purposes of study into (1) improvement and perfection of the work situation, sometimes called job standardization, (2) motion study and training of workers, and (3) setting of job times.

Job Standardization.—Job standardization denotes the establishment of the best possible conditions with respect to all physical factors which influence the job and is a first natural objective in all motion and time study work. A new plant, laid out, designed, built, and equipped ready for operation by progressive managers and experienced engineers will presumably be ideal with respect to job standardization. Where ideal conditions cannot be realized in existing workshops the best standards attainable can be set and maintained. Some of the conditions that should be studied are:

EQUIPMENT. A study of existing equipment may suggest changes and improvements or repairs. The need to bend over, to lift heavy materials or parts, to take more than a step or two, slows up the work and tires the operator; which suggests the economical utilization of mechanical devices. Processes should be those which combine economy with uniformity of standard quality. Standard times and methods are dependent upon standardization of machines within each class, and the maintenance of normal conditions with respect to their upkeep. Proper means of transporting and handling materials must be utilized.

TOOLS. Assurance must be had that the proper tools needed for a given task will be available. This phase of the investigation will consider the tool room organization and administration, the selection of proper steels, shape, size, variety, and tempering of tools, procedure in issuing them when needed, and their repair and resharpening after use. Likewise

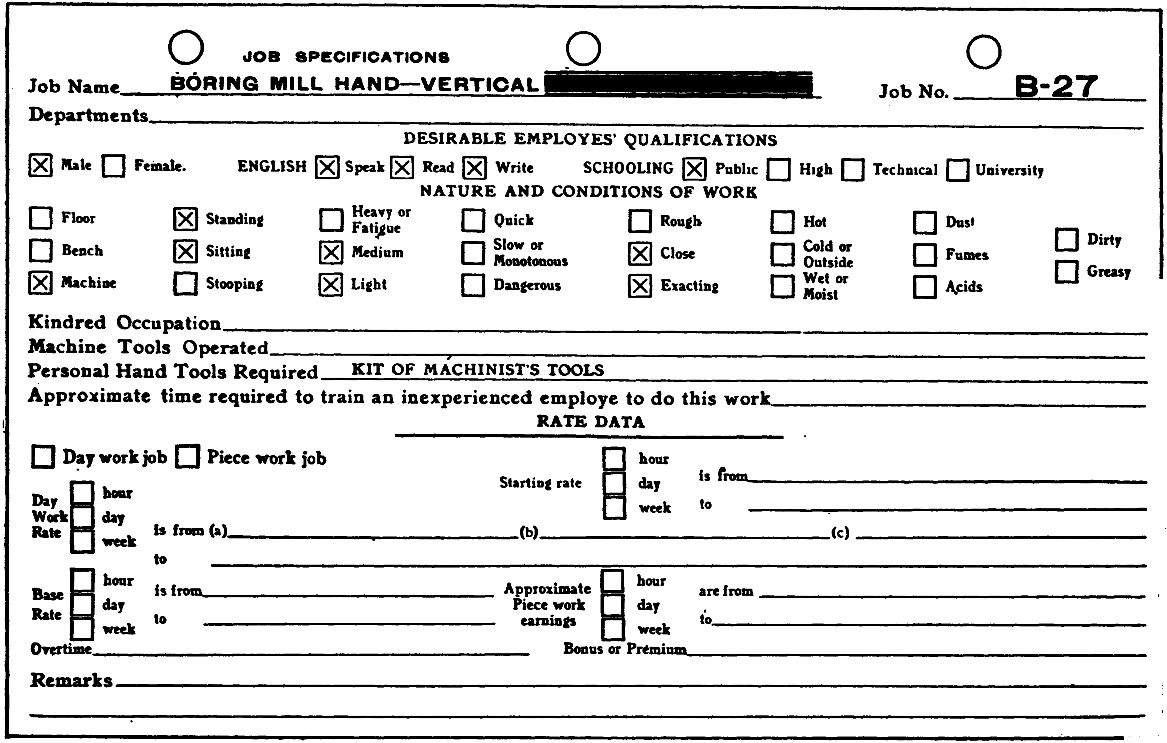
all necessary auxiliary equipment in the way of bolts, blocks, clamps, dies, jigs, etc., should be standardized—perhaps for each operation—kept in good condition, and made readily available.

MATERIALS. Economy in the use of materials should be studied, considering comparative values of material and labor. The latter may be a relatively unimportant item. Waste should be considered, remembering that workmen constantly handling a material may become careless and insensible to its value. Disposing, reclaiming, or utilization of waste should be provided for. Considering the consumer's use of the product and methods of manufacture, the kind and grade of material used should be analyzed. Another material may be better, a cheaper grade prove as suitable, or a better grade may be less expensive to process and the finished product more uniform as to quality. A study of storeroom practice may suggest ways of eliminating delays in the issuing of materials.

LAYOUT. All the machines and workplaces in the department have a relation one with another, and must be considered together. Departmental arrangement is important. A uniform, maximum flow of materials in process is the aim. To achieve this, moves between operations should be short, space sufficient, inspection points and storage areas provided for, production facilities balanced so that congestion will not take place at certain points, with perhaps idle work areas at others. Tool, store, and stockrooms must be readily accessible and service centers convenient. Most factories grow by adding manufacturing space here and there, until finally production arrangements are haphazard. In one instance the path of travel of a part was reduced from 535 feet to 27 feet, four truck trips including two elevator journeys dispensed with, and the method changed to require four operators instead of five. Much time was saved.

ENVIRONMENT. Intelligent attention will be given to adequate illumination, ventilation, sanitation, comfort of floors, unnecessary noises or objectionable odors, and danger hazards. Environment makes its impress upon the worker and is reflected in his work; hence it should be good.

Adjustments and changes suggested by the foregoing analysis may be few and unimportant, or they may be extensive and costly, requiring many months for completion. When the work is completed provision must be made for the maintenance of the standards established. Best performances are possible only when conditions are "right," and standard performances possible only when conditions do not vary materially.



JOB SPECIFICATIONS

Job Name BORING MILL HAND—VERTICAL [redacted] Job No. B-27

Departments

DESIRABLE EMPLOYES' QUALIFICATIONS

☒ Male ☐ Female. ENGLISH ☒ Speak ☒ Read ☒ Write SCHOOLING ☒ Public ☐ High ☐ Technical ☐ University

NATURE AND CONDITIONS OF WORK

☐ Floor ☒ Standing ☐ Heavy or Fatigue ☐ Quick ☐ Rough ☐ Hot ☐ Dust ☐ Dirty

☐ Bench ☒ Sitting ☒ Medium ☐ Slow or Monotonous ☒ Close ☐ Cold or Outside ☐ Fumes ☐ Greasy

☒ Machine ☐ Stooping ☒ Light ☐ Dangerous ☒ Exacting ☐ Wet or Moist ☐ Acids

Kindred Occupation

Machine Tools Operated

Personal Hand Tools Required KIT OF MACHINIST'S TOOLS

Approximate time required to train an inexperienced employe to do this work

RATE DATA

☐ Day work job ☐ Piece work job

Starting rate ☐ hour ☐ day ☐ week is from to

Day Work Rate ☐ hour ☐ day ☐ week is from (a) (b) (c)

to

Base Rate ☐ hour ☐ day ☐ week is from to

Approximate Piece work earnings ☐ hour ☐ day ☐ week are from to

Overtime

Bonus or Premium

Remarks

Figure 108a. Job Specification Card

Job Name BORING MILL HAND—VERTICAL [redacted] Job No. B-27

THE DUTIES OF THIS JOB ARE:

To set up and operate a Vertical Boring Mill on all classes of work.

THE NECESSARY EMPLOYE QUALIFICATIONS TO FILL THIS JOB ARE:

(1) Must be an experienced mechanic who is able to take care of and operate a Vertical Boring Mill on all classes of work, working to samples, drawings or instructions, interpreting mechanical requirements and figuring necessary dimensions.

(2) Should be skilled in the use of modern tools and measuring instruments such as micrometers, calipers vernier calipers, gauges, protractors, dividers, surface gauges, etc.

(3) Must be able to make layout, set up, placing, blocking, bolting and clamping large or small, heavy or light springy parts and be capable of very accurate machining of same.

(4) Must be capable of grinding and setting the different tools used.

(5) Must be thoroughly experienced in Vertical Boring Mill methods, such as facing, boring, undercutting, turning taper fits and working to close measurements.

(6) Must have a working knowledge of the proper feeds and speeds to use in order to get the best results with different kinds of material.

Remarks

Figure 108b. Reverse of Job Specification Card

Motion and time study brings about a great change in the relation of auxiliary departments to the operating departments, and the attitude of executives. Ordinarily the job, as represented by the man doing it, has little option but to accept equipment, arrangements, tools, materials, environment, etc., as they come. The worker is at the bottom of the ladder of authority. With motion and time study job requirements are analyzed and standardized in every particular; the service required of auxiliary departments and executives is outlined in minute detail, and

Figure 109. An Assembly Workplace Resulting From Job Standardization Efforts

effective functioning checked at every turn. The job is now supreme, and workmen in a position to demand effective management. This is as it should be, for mental inertia and laziness are as prevalent among one group as the other.

From the foregoing it is evident that job standardization work is best accomplished by first considering the plant as a whole. The functions and relation of departments to each other may be studied, general methods of operation, and finally the details of each workplace or machine.

Selection and Training of the Worker.—An analysis will have been made of the requirements of each task from an operator standpoint, and cards like the one shown in Figures 108a and 108b will be in the files of the supervisor and the employment department. Requests for workers

are then made by job number, which enables the personnel department to make preliminary selections and refer desirable applicants to the foreman for final acceptance. New employees must then be trained in the proper way of performing tasks.

Figure 109 shows a picture of an assembly workplace following job standardization efforts. Note the fixtures for holding the work, the placement of piece parts, the prepositioned screwdriver. Consider the simplicity and ease of accomplishment. Figure 110 shows a set-up of the workplace.

Figure 111, a process chart showing how the job is performed, is also used as an instruction card for training new operators.

Pos. #1. & #2.
METHOD SPECIFICATION

Date ____

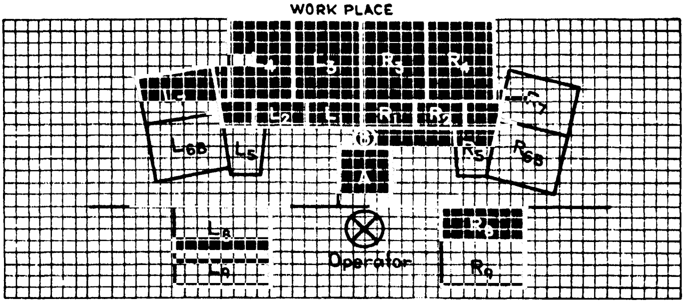
DRAWING NO. ____ M.S. No ____

Apparatus ____ Time Study No. ____

Operation Assb. washer to motor, 2 set shafts, cam shaft, 2 springs, 2 sleeves, 2 gears, set hand shaft, sleeve, switch blade, backplate and 4 screws to supp. plate.

Operator ____ Observer ____

WORK PLACE



FIXTURES AND STOCK LOCATIONS

A. Fixture
B. Yankee Screw Driver
C. Vaseline

L1.	Short spacing sleeve	R1.	Spacing sleeve (long)
2.	Screw 4-43 - 5/16" Rd. Hd.	2.	Screw 4-48 x 1/2" Rd. Hd
3.	Idler Gear Assb.	3.	Minute Hand shaft assb.
4.	Assb. of set hand shaft	4.	Switch blade assb.
5.	Washer	5.	Spring
6.	Setting Shaft	6.	Set Shaft
7.	Spring	7.	Cam Assembly
8.	Field & core assb.	8.	Rotor
9.	Support plate assb.	9.	Back plate

Figure 110. A Set-Up of an Assembly Workplace Resulting From Job Standardization Efforts

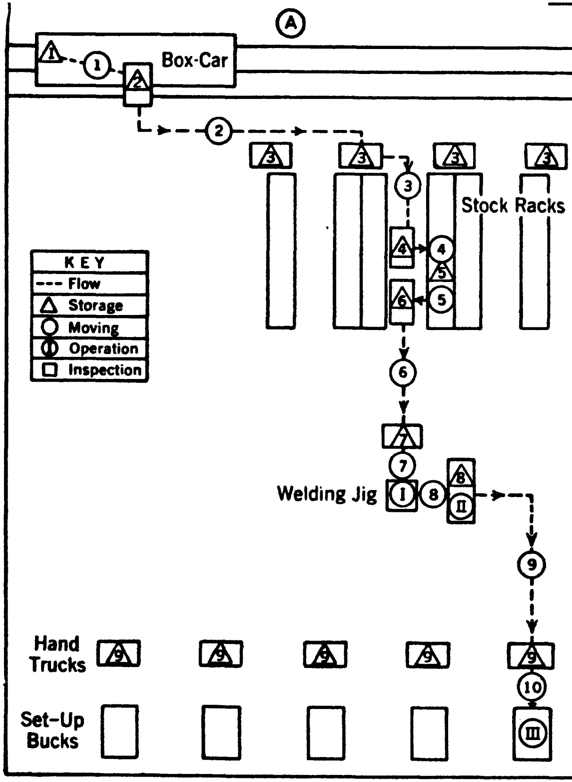
METHOD SPECIFICATION - SEQUENCE OF MOTIONS Pos. #1 & #2.

LEFT HAND	RIGHT HAND
1. Get & pl. supp. pl. assb. L9 to A.	1. Dispose of fin. assb. A to Con.
2. Get & pl. spring on cam assb. R5 to A	2. Get & hold cam assb. R7 to A.
3. Get & pl. spring on cam shaft L7 to A	3. Hold cam assb. A
4. Assist	4. Place cam assb. in support plate in fixture A.
(Step on foot pedal)	
5. Assist	5. Wind spring on cam shaft
(Release foot pedal)	
6. Get & pl. set shaft L6 to A.	6. Get & pl. set shaft R6 to A.
7. Get washer & assb. to rotor L5 to A.	7. Get & hold rotor R8 to A.
8. Get & hold field & core assb. L8 to A.	8. Assb. rotor to field & core assb.
9. Place motor assb. on supp. pl.	9. Assist
10. Assist & throw catch on fixt. A.	10. Get & pl. switch blade R4 to A
11. Assist	11. Get & pl. backplate R9 to A.
12. Get & pl. screw L2 to A	12. Get & pl. screw L1 to A.
13. Get & pl. screw R2 to A	13. Get & pl. screw R2 to A.
14. Assist	14. Get screw driver & drive four screws B to A.
(Step on foot pedal to release assb.)	
15. Remove Switch from fixt. & lay on backplate.	15. Release scr. dr. & assist.
16. Get & pl. sleeve on set sh. R1 to A.	16. Get & pl. sleeve on set sh. R1 to A.
17. Get & hold set hand shaft L4.	17. Get & apply vaseline C to shaft.
18. Hold shaft	18. Get & pl. sleeve L1 to shaft
19. Place shaft thru supp. pl. & backplate.	19. Assist
20. Get & place idler gear assb. from L3 to A.	20. Get and place minute hand shaft assb. from R3 to A.

Figure 111. Process Chart for Operation Shown in Figures 109 and 110

The Process Chart.—Process charts are an aid in effecting improvements. They are of three kinds: (1) the flow chart, (2) the man and machine chart, and (3) the right- and left-hand chart. Questions which should be asked when preparing such charts are as follows:

1. *Why* should the work be done?
2. *What* is to be done?
3. *How* is the work to be done?
4. *Who* is to do the work?
5. *Where* is the work to be done?
6. *When* is the work to be done?



	Operations (B)	Distance	Pick-up Lay-down	How Moved
△1	In Box Car			
1	Load on Truck	10 Ft.	1	Hand
△2	On Truck			
2	From Box Car	50 Ft.		Hand Truck
△3	On Truck			
3	To Racks	30 Ft.		Hand Truck
△4	In Truck			
4	Unload to Racks	10 Ft.	2	Hand
△5	In Racks			
5	Load on Truck	10 Ft.	2	Hand
△6	On Truck			
6	To Welding	100 Ft.		Hand Truck
△7	Ahead of Welding			
7	To Welding Operation "I"	3 Ft.	1	Hand
I	Spot Weld Braces			
8	From Welding Jig to Truck	3 Ft.	1	Hand
△8	On Truck			
II	Gas Welding			
9	To Back of Set-Up Buck	100 Ft.		Hand Truck
△9	On Truck			
10	To Set-Up	15 Ft.	1	Hand
III	Welding in Set-Up Buck			
	SUMMARY			
9	Storing (Non-Productive)			
10	Moving (Non-Productive)	331 Ft.	5	
3	Operations (Productive)		3	

Figure 112. Process Flow Chart of Rear Quarter Panel Assembly of Automobile Body
(From educational material of Fisher Body Division, General Motors Corp.)

PROCESS CHART

PRESENT METHOD — GEAR HUB-3786506-2

Price $15.00 Operator - $9.80 for Helper

Rough bore flange and O.D. to 3/16" on side

OPERATOR			HELPER			MACHINE		
1	Get long calipers 700')	36.0	1	Assist operator	36.0			
2	Put blocks in positions on mill)							
3	Get drg. 700')							
4	Personal)							
5	Lift to mill 12'	8.0	2	Help with rigging	8.0			
6	Go after tools 700'	6.0	3	Sweep up	1.0			
7	Personal	2.0	4	Wait for operator	7.0			
8	Get a driver	1.0	5	Look for driver	1.0			
9	Tighten driver	1.0	6	Wait for operator	1½			
10	Look for wrench	½						
11	Tighten driver	½	7	Tighten driver	½			
12	Centrally locate hub on mill table by tightening driver	2.0	8	Tighten driver	2.0			
61	Grind tool 100'	3.0	57	Wait for operator	3.0			
62	Wait for cut	12.0	58	Wait for cut	12.0	11	Continue facing flange	12.0
63	Grind tool 100'	3.0	59	Wait for operator	3.0			
64	Wait for cut	19.0	60	Wait for cut	19.0	12	Continue facing flange	19.0
65	Place a Carboloy tool in No.1 head (wrong use of tool) (did job however)	3.0	61	Assist operator	3.0	13	Continues both faces	12.0
66	Wait for cut	18.0	62	Wait for cut	18.0	14	Cut under face of flange	6.0
67	Check depth of hub rim from flange (cast ¼ too low)	3.0	63	Wait for operator	3.0			
68	Remove tool from head No.1 and replace it with another	4.0	64	Assist operator	4.0			
69	Wait for cut	11.0	65	Wait for cut	11.0	15	Face rim of O.D. 60'/min. 1/8" feed - 1/4" cut	11.0
70	Wait for cut	42.0	66	Wait for cut	42.0	16	Face rim of O.D. (2 cuts) 70'/min. 3/32" feed - 1/4" cut	42.0
71	Setup turning tool for rim of flange	7.0	67	Assist operator	7.0			
72	Check up caliper dim.	1.0	68	Help check	1.0			
73	Start cut and check O.D. with calipers	1.0	69	Help check	1.0			
74	Wait for cut	20.0	70	Wait for cut	20.0	17	Turn O.D. of rim of flange 70'/min. 3/32" feed - 1/4" cut	20.0
75	Check height of flange above spokes	4.0	71	Assist operator	8.0			
76	Change to another Carboloy tool	2.0						
77	Set tool	2.0						
78	Wait for cut	17.0	72	Go for box 200'	1.0	18	Rough face inside hub, speed 80'/min feed 3/32" cut 3/16"-1/4"	17.0
103	Return drg. 700'	7.0	98	Pick up blocks, etc.	4.0			
			99	Carry scrap bolts etc. to scrap pile 80'	1.0			
			100	Pick up blocks, etc.	2.0			

SUMMARY

OPERATOR		HELPER		MACHINE	
Total time	788	Total time	788		
Total foot travel	6,870 ft.	Total foot travel	3,700 ft.	Working time	397.5
Wait for cut	387.5	Wait for cut	307.0		
Wait for inspection	42.0	Wait for inspection	42.0		
Wait for crane	11.0	Wait for crane	11.0		
Handling	294.5	Wait for operator	66.0		
Machine repair	53.0	Handling	309.0		
		Machine repair	53.0		

Total time 13.15 hours

Total travel - both - 10,570 ft. - 2 miles

Waiting for cut $= \frac{387.5}{788} = 49.2\%$

Handling time $= \frac{294.5}{788} = 37.4\%$

Figure 113. Man and Machine Process Chart

"The flow process chart is made by following materials, men, or paper records through the entire process. It shows the route of the object from the beginning of the process to the end, keeping that one object in mind. Wherever a move occurs, the distance of travel is shown." [5] Figure 112 shows such a chart which indicates the steps in the assembly of a rear quarter panel assembly of an automobile body.

Man and machine charts reveal any delays or inconsistencies in the use of machine equipment. The machine time used may be much more important than labor time. The chart in Figure 113 records starts, stops, machining operations, and idle machine time in relation to the movements of the operator and, in this case, his helper. The chart does not break down operations into elements or analyze details of the work procedure. Charts of this kind, by showing what is done, distances, and time values, provide a basis for considering alternate proposals.

A right- and left-hand chart used for instruction purposes is shown in Figure 111. The operation consists of a sub-assembly of small parts. In this case the work of each hand is stated. Time values are not given, although they are included on analysis charts. The finished work is delivered conveniently to the conveyor, which passes under the center bins just in front of the fixture.

Motion Study.—The manufacturing plant, if it is to function smoothly and economically, must have its departments arranged conveniently. Its operating and auxiliary activities must be organized to produce goods and services with minimum expenditures of time, energy, and waste. This implies simplified coordinated work arrangements and ease of accomplishment. Motion study may be applied with equal effectiveness to office and factory situations.

Motion study involves an analysis of the movements made in performing an operation with the object of eliminating useless and fatiguing motions and arranging the necessary ones in a logical sequence. It is an aid to job standardization work in suggesting proper facilities as crane service, standardized workplaces, or improved arrangements. Utilizing these proper facilities, the motions which the worker makes in performing the task are then subject to study.

Effort is made to achieve a method of performance which is simple, direct, and easy, and in which results are attained by straight, short, and quick motions which succeed each other naturally, establishing a rhythm and harmony of action of the hands and body that make for accuracy, speed, and minimum fatigue.

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[5] "How to Set Up a Program for Motion Economy," by Allen H. Mogensen. *Supplement to Factory Management and Maintenance,* Vol. 94, No. 5.

Thoughtful observation of a worker and consideration of the significance of his movements, of the machinery, tools, and accessory equipment used, of incidental delays, the receipt of materials, manner of its handling and of the disposal of his finished work, may well suggest action leading to increased productivity at less cost and with less effort. A machinist turning out 198 castings a day, each weighing 35 pounds, in carrying them to and from his machine walked over two miles a day under load. By rearranging his stock trucks he at once doubled his output and earning capacity. An extreme case perhaps, but innumerable instances of time

Name of Symbol	Therblig Symbol		Explanation-suggested by	Color	Color Symbol	Dixon Pencil Number	Eagle Pencil Number
Search	Sh.		Eye turned as if searching	Black		331	747
Find	F.		Eye straight as if fixed on object	Gray		399	747½
Select	St.		Reaching for object	Gray, light		399	734½
Grasp	G.		Hand open for grasping object	Lake red		369	745
Transport loaded	T.L.		A hand with something in it	Green		375	738
Position	P.		Object being placed by hand	Blue		376	741
Assemble	A.		Several things put together	Violet, heavy		377	742
Use	U.		Word "Use"	Purple		390	742½
Disassemble	D.A.		One part of an assembly removed	Violet, light		377	742
Inspect	I.		Magnifying lens	Burnt ochre		398	745½
Pre-position	P.P.		A nine-pin which is set up in a bowling alley	Sky-blue		394	740½
Release load	R.L.		Dropping content out of hand	Carmine red		370	744
Transport empty	T.E.		Empty hand	Olive green		391	739½
Rest for overcoming fatigue	R.		Man seated as if resting	Orange		372	737
Unavoidable delay	U.D.		Man bumping his nose, unintentionally	Yellow ochre		373	736
Avoidable delay	A.D.		Man lying down on job voluntarily	Lemon yellow		374	735
Plan	Pn.		Man with his fingers at his brow thinking	Brown		378	746
Hold	H.		Magnet holding iron bar	Gold ochre		388	736½

Figure 114. Therbligs, Symbols, and Color Designations
(From Motion and Time Study, by Ralph M. Barnes, John Wiley & Sons, Inc.)

savings ranging upward from a few per cent are being effected. Preliminary stop-watch studies may aid in judging the relative worth of alternate methods and reveal facts not apparent from observation.

Therbligs.—Frank B. Gilbreth coined the word "therblig" (Gilbreth spelled backwards) to denote subdivisions of work effort which are common to all kinds of work. They approximate fundamental motions and are generally used in motion analysis work.

Classification of Hand Motions.—Economy of time and effort is achieved by attention to the movements which are necessary in performing a task. All hand motions may be divided into five general classes as follows:

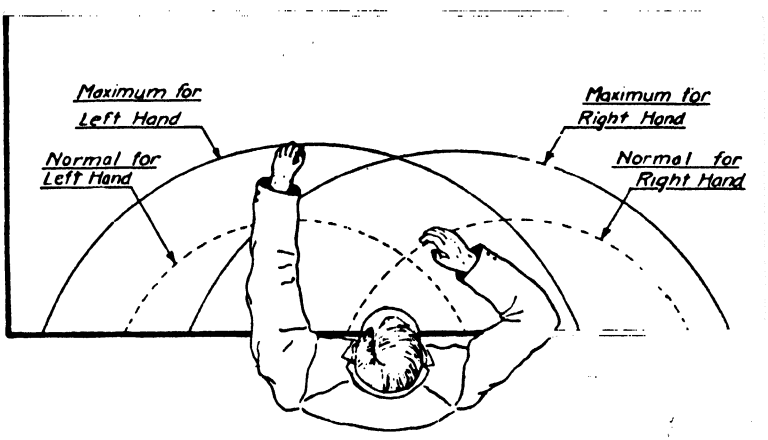


Figure 115. Illustration of Normal Work Areas

1. Finger motions.
2. Motions that involve fingers and wrists.
3. Motions that involve fingers, wrists, and forearm.
4. Motions that involve fingers, wrists, forearm, and upper arm.
5. Motions that involve fingers, wrists, forearm, upper arm, and shoulder.

Each class, in the order given, requires more time and effort in performance. It is desirable, therefore, to plan work so that it may be performed with the simplest motions possible. Figure 115 shows the influence of this idea in bringing about circular workplaces. "Materials and tools should be located within the normal working area and with

respect to the lowest classification of motions permitted by the character of the work." [6]

Micromotion Study.—By using a motion picture camera a film record of any operation may be obtained which discloses time values for fundamental motions. Time values are obtained by using marked film in a standard speed camera, or including a high speed clock in the picture.

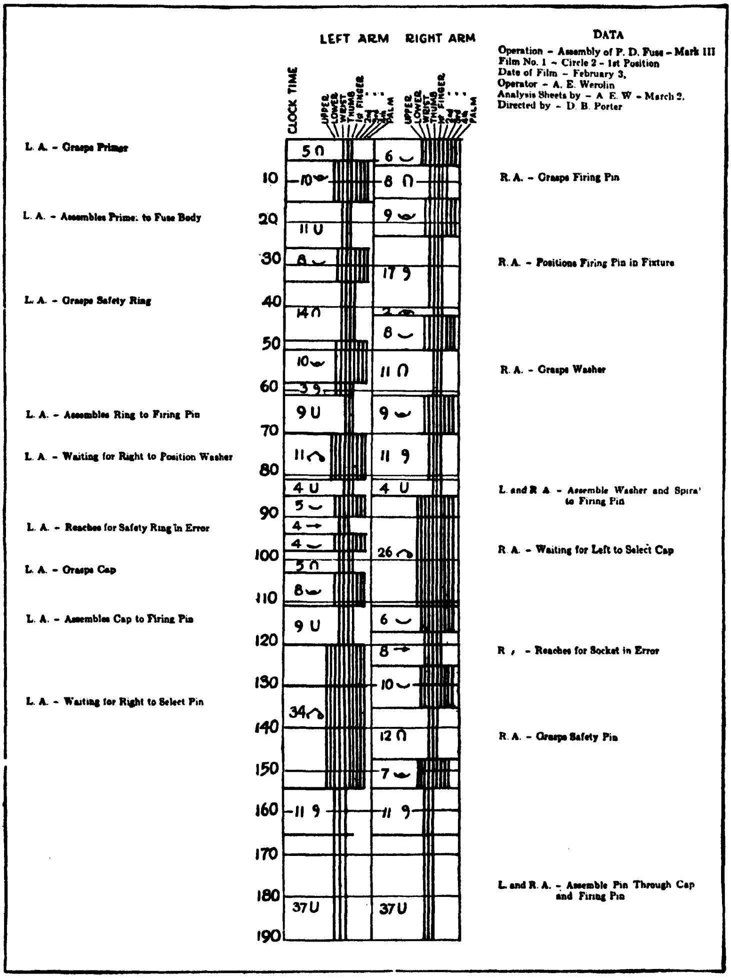


Figure 116. An Example of Simo Charts

[6] "How to Set Up a Program for Motion Economy," by Allen H. Mogensen, *Factory Management and Maintenance*, Plant Operation Library.

The film also provides a record of the working arrangements, machines, and tools. The resulting pictures may be analyzed and studied intensively with the principles of motion economy in mind.

Using a projector, micromotion film may be run slowly, speeded up, stopped, or run backwards at the will of the operator. Particular parts may be studied repeatedly. In this way ideas are gained for improvements. The data on the film are transferred to analysis sheets showing what each hand does separately; also foot or other body motions, if included and desired. Time values are recorded in units of 1/2,000th of a minute, as shown by the clock or marks on the film.

Simultaneous motion cycle charts, called simo charts, may be made from the film or from the analysis chart. In this way deficiencies in methods may be detected, and improvements effected. Charts may be developed to show proposed methods.

Because of the cost, micromotion studies are not used in a study of all jobs. They are valuable as a means of improvement in methods, when the cost warrants, and for education and training purposes.

Teaching Motion Economy.—In past years management's plan was to control and direct from the top down in the organization. Employees were expected to carry on as instructed. The present-day practice is to interest all employees in the idea of motion economy and the benefits which accrue from it, and thus obtain their contributions of ideas and more effective cooperation. To this end programs of education are carried on for both supervisors and workmen. New employees are given special attention. If enthusiasm can be aroused, everyone in the shop becomes "motion-minded," and all help to manage.

Administration and Production Control.—The productivity of a department or a work station will be influenced by the success with which work in process is controlled, and the smoothness with which the administrative machinery functions. Production centers must be coordinated, delays and interruptions anticipated and guarded against, and supply and auxiliary service departments made efficient.

It should be appreciated that while motion study accompanied by the suggested job standardization work invariably results in increased output this is not accomplished by speeding up the worker, but by reducing friction, training in proper methods, and removing obstacles that he has previously needed to overcome. Poor lighting or deficient ventilation slows up the worker, while the need to manipulate a machine which can be made to operate automatically, or to lift and carry a 50-pound casting 10 or 15 feet every few minutes are obstacles to easy, rapid work.

Continuity of Job Standardization, Motion Study, and Time Study.—It is not to be inferred that job standardization, employee training, and time study are always three distinct phases of motion and time study, each completed in entirety for a department or plant before the succeeding step is begun. When the work is inaugurated in an existing plant this procedure is to be recommended if times set are to prove equitable, for changes and improvements effected for the benefit of one operation will influence the time for doing others. In a new plant the first step and much of the second will have been cared for in its design, construction, and equipment.

In going plants, however, with well-established motion and time study departments the situation is somewhat different. Industry is not static and the evolution constantly taking place necessitates changes and readjustments. New methods are introduced, improved equipment is added, the product is altered in design, or possibly new items are added. Materials are constantly being replaced by others, newly developed and more suitable or cheaper to use. Recent years, for example, have seen the development of plastics, decalcomania, drop forgings, aluminum and steel castings, pressed steel, and punched parts. Likewise machine improvements offer possibilities for combining operations, and perfection of processes for simplification. For example, the introduction of quick-drying lacquers has cut down by many days the production time for this phase of work, and greatly decreased the space and facilities needed. This typical situation calls for continual revision of obsolete task times and the setting of standards for new operations. In all such cases job standardization and motion study work will be carried on as a preliminary to each and every stop-watch study of an individual task or operation. The work is never finished.

CHAPTER 23

MOTION AND TIME STUDY—TAKING TIME STUDIES

Stop-Watch Study.—The primary purpose of stop-watch studies is to record operation times and provide a basis for setting rates. It is the third and final phase of motion and time study as carried on in the average plant, where motion study is not utilized with the degree of refinement suggested by micromotion and simo charts. With facilities for doing a task and the conditions surrounding it at their best and standardized, and with the worker trained in the best method of accomplishment, studies with a stop-watch enable an observer to determine the time it *should* take to perform the task. Rates set in this manner will be based upon facts and relatively fair as compared with each other.

Setting Times Without Making Time Studies.—Methods of setting task times which are less satisfactory than detailed time studies, but which may be used in understandardized shops, are: (1) comparison with past performance, (2) judgment of the foreman, (3) sending through trial lots, and (4) utilizing fundamental machine data supplied by equipment manufacturers together with the experience of shop executives.

All these methods have defects. Past performances are not a fair guide. One job may be done by qualified men working with enthusiasm; another by mediocre mechanics or poor workmen without interest in their jobs. In any event, good men and poor ones will be employed. If rates are set on a basis of past performance the good men already doing a good day's work will enjoy but slight wage increases; while the poorer workmen by simply becoming proficient and endeavoring to do a fair day's work will profit greatly. The first group are penalized because of their skill and previous application; the second capitalize previous incompetency. Then again, the conditions under which jobs are done change, and the elements included under a job title vary. Lacking reliable records these changes may not be evaluated accurately or may even escape notice so that rates set on this basis are likely to be both unfair in themselves and inequitable as compared with other rates, and hence cause dissatisfaction.

The foreman's judgment will prove fallible in the same respects, as he cannot be expected to possess superior skill in all the work which he supervises; guesswork inevitably plays a part in his attempts at rate-

setting. Favoritism may manifest itself. Conditions may not be right, methods may be wrong, and the worker may be endeavoring to influence the setting of a favorable time. Sending through trial lots provides information of the time which an operation *does* take, but not necessarily data as to the time it *should* take, for the reasons just noted. Utilizing machine tool data with experience of executives provides an approximation to time study, but is a compromise. It usually denotes a desire on the part of management to inaugurate motion and time study work, and suggests the possible opposition of the workers to its use. To an increasing extent management and men are favoring the use of motion and time study as the one best method of setting task times.

The improvement effected by standardization work and training in best methods that precede stop-watch studies are the phases of study that enable work to be accomplished in minimum time. Stop-watch studies tell men and management what that time *should* be and eliminate cause for disagreements on this vital point.

The Time Study Observer.—The time study observer should be thoroughly experienced in the work which he is analyzing If he is capable of performing the task as an operator it is even better, because of the effect upon those doing the work. He should recognize the aim and value of each motion made, and judge the handling of equipment from an intimate knowledge of its possibilities and operation. The manual of standard practice instructions prepared by one large organization for its time study operators states:

> The observer should understand in minute detail the particular operation on which he is for the time engaged. He must detect all defects and shortcomings such as incorrect speeds, dull and unsuitable tools, all false and useless moves, all hesitancy and "stalling" on the part of the operators, all delays due to imperfect jigs and machinery, the wrong locations and disposition of material, and inexpert manipulation of equipment.

Other desirable qualifications in addition to knowledge of the task are: (1) experience as an observer, (2) the power of analysis, (3) mechanical skill and judgment, (4) ingenuity, self-confidence and initiative, (5) tact, (6) self-control, patience and persistence, and (7) an honest, impartial attitude toward his work. High school graduates with shop experience, who are otherwise qualified and ambitious, make good observers. The observer must inspire confidence in and win the cooperation of both management and employees, and must bear in mind that his work has a far-reaching effect as it raises or lowers plant morale and affects costs.

Antagonism has been aroused against stop-watch study procedure because of (1) a lack of understanding of its aims and purposes, (2) incompetent observers, and (3) attempted secrecy of operation. The observer can do much to correct the hostile attitude engendered in the minds of the great body of workers by such errors of the past. Fairness and frankness with workers are necessary, together with a full explanation of methods used and of the completed studies. There should be no mystery about motion and time study. Attempted secrecy is unwarranted and arouses justifiable suspicion of selfish motives.

Cooperation of Foremen Needed.—The cooperation of superintendents and foremen is essential to effective work. A critical aloofness by those in charge will result in open hostility and antagonism from the rank and file. Foremen are extremely sensitive to any encroachment upon their authority or any suggestion of their lack of a thorough knowledge of every job in their departments. Particularly they resent any action or word which will lessen their hold on their men as an assumption of arbitrary authority by the observer, or a parading of the foreman's ignorance before his men. The observer will approach the foreman as an assistant, consulting and advising with him, and securing his approval of all that is done. The foreman must be in the foreground rather than the time study man. The latter must seek to inform, educate and interest the foreman while ostensibly assuming a knowledge on his part that cannot reasonably be expected. When it is evident to the foreman that the department can make a better showing under the new order, and that his position as a boss is strengthened, his assistance can be depended upon. With cooperation, information and data of past practice are forthcoming. Workmen will follow the example set by the boss, and by suggestions, wholesome criticism and hearty cooperation will make the observer's task easier and the results better. With confidence established and the incentive of increased earnings provided, the skilled worker frequently proves to be a first-class industrial engineer within the sphere of his own job. The observer should utilize this fund of information and ideas, possibly gained through years of experience.

Selection of Worker to Be Studied.—When making a stop-watch study, the operators selected for observation should be better than fair or average, but not necessarily highly skilled or expert. To select the most expert worker is to make a bad impression on the others, who will imagine that task standards are to be set unduly high. A fair or average man, on the other hand, will not work smoothly or steadily, or attain proficiency with new methods quickly enough. As a result, variables will enter into the study which make its taking more difficult and which must

be eliminated. The motions of a good worker are simple and direct—in harmony with the task. With poor operators, hesitation, false motions, and abnormal times make more studies necessary, and the results less dependable. For the effect on the shop, and for comparative purposes, it is sometimes a good idea to take studies on workers of different abilities.

When it comes to setting the task, after the studies are completed, two things should be borne in mind: The first is that of the several types of

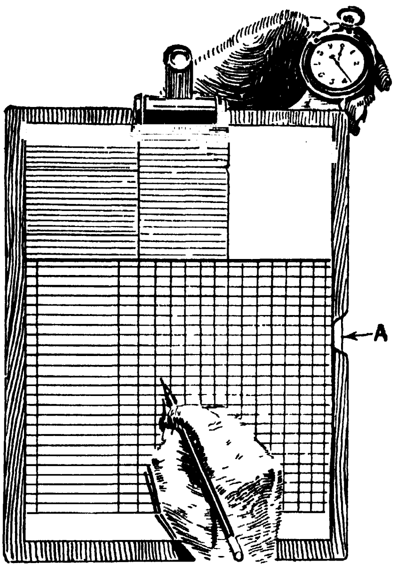


Figure 117. View of the Hough Time Study Board

"A" is pocket for storage of blank sheets and data

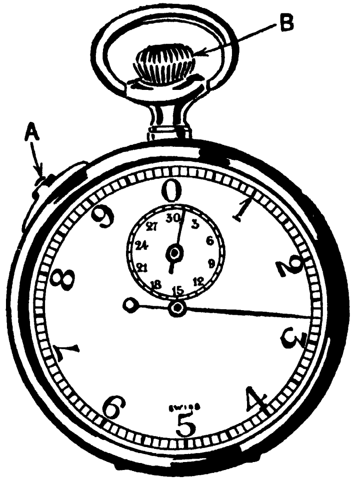


Figure 118. Plain Decimal Stop-Watch

workmen; the average man is the one who represents the majority of the workmen in industry, and the task set should be fair to him; the second is that the value of a fast man should be appreciated and he should be permitted to earn more money—as much as he is able to make. The observer's aim is to establish a rate of output which can be maintained over a period of years—an industrial lifetime—with fairness to the worker. If a first class worker is not available, the proficiency of the operator studied will need to be evaluated by the observer and the time adjusted accordingly.

Efforts on the part of a worker to deceive an observer are seldom successful. Hesitation, false motions, slowness, or awkwardness are quickly apparent. Attempts to stall will be detected because the worker

cannot be successful in stalling at the same points in the operation cycle or for the same lengths of time: his element times will vary considerably. If working sincerely, they will be fairly constant. With, say, ten readings covering each element, the abnormal times may be readily picked out. A skilled operator working at a uniform pace slightly below his usual standard might possibly mislead the observer, but this is not probable.

Equipment for Taking Time Studies.—The equipment required for taking time studies is relatively simple and inexpensive. Observation sheets, a decimal stop-watch and a time study board suffice in most cases. A hand-counter or a speed indicator for determining shafting speeds may be required, while a slide rule and a comptometer or an adding machine for making computations will expedite the work. Figure 117 shows a standard time study board. The board is held on the left arm and the watch operated with the left hand, which leaves the right hand of the observer free for note taking.

The ordinary stop-watch used registers time in hundredths of a minute with the large hand, which makes one revolution per minute; and records consecutive minutes up to 30 with the small hand on the small dial. (See Figure 118.) The movement of the watch and the hands are set in motion by moving the slide on the side (A), and stopped but the hands not returned to zero by a reverse motion. Pressure on the top of the stem (B) returns the hands to zero, but does not stop the watch movement or the hands, which instantly record time from the zero point again. The split-hand watch has an additional large hand which may be controlled independently of the others. It operates normally with the other big hand but can be stopped at will; when released it again accompanies the big hand. This arrangement permits the extra hand to be stopped as the worker finishes an element of the task. When the reading is noted and recorded on the time study sheet, the hand is released to travel with the other one, until stopped similarly again.

THE TECHNIQUE OF STOP-WATCH STUDIES

The actual taking of stop-watch studies may be discussed under five headings, denoting successive steps in the procedure: (1) preliminary work; (2) dividing the operation into elements; (3) the observation sheet records; (4) methods of taking times; and (5) determining proper operation times. The latter step involves establishing base times, perhaps noting deviation ratios, and making necessary allowances.

Preliminary Work.—Unless job standardization work has recently been thoroughly done, the time study observer will have a certain amount

of preliminary work to do. This is normally the case in day-by-day practice. Therefore the observer will confront his task with an inquiring mind as suggested in the preceding discussion.

The observer will note the condition of any machinery and equipment used, and see to it that machine feeds and speeds are in accordance with standards. In the "line up" of the job he will note that the workman is supplied with the proper tools and the work arranged most conveniently both for doing the work and also for disposal of the finished product with least exertion. It is often desirable to make a few preliminary studies with the watch to get "the run" of the work, to note interruptions which are occurring, to see that the work is being done correctly, and perhaps to accustom the operator to being timed. Some preliminary training and instruction of the operator may be necessary.

All of this work will afford the opportunity to get acquainted with the operator and to win his confidence and cooperation. When the study is finished, the operator can be shown the study and an explanation offered of the allowances made for work incidental to the job, not overlooking anything for which he should be paid. The worker will inevitably be favorably impressed when he sees efforts made to reduce fatigue incidental to his job, to eliminate faulty machine conditions, and to provide him with proper light and ventilation, with properly sharpened tools, and to prevent interruptions and delays which reduce his earning capacity. There is opportunity at this point for cooperation of the observer, workman, foreman, and inspector to the end that all aspects of the job situation be thoroughly considered before standards are established.

Dividing the Operation into Elements.—The taking of preliminary time studies aids in determining upon a division of the task into elements or sub-operations if these have not already been agreed upon in a motion analysis. They should be distinct, single, continuous phases or parts of the task, with definite beginnings and endings. In many plants standard terms are used for frequently recurring elements and these are carefully defined, as for example the following:

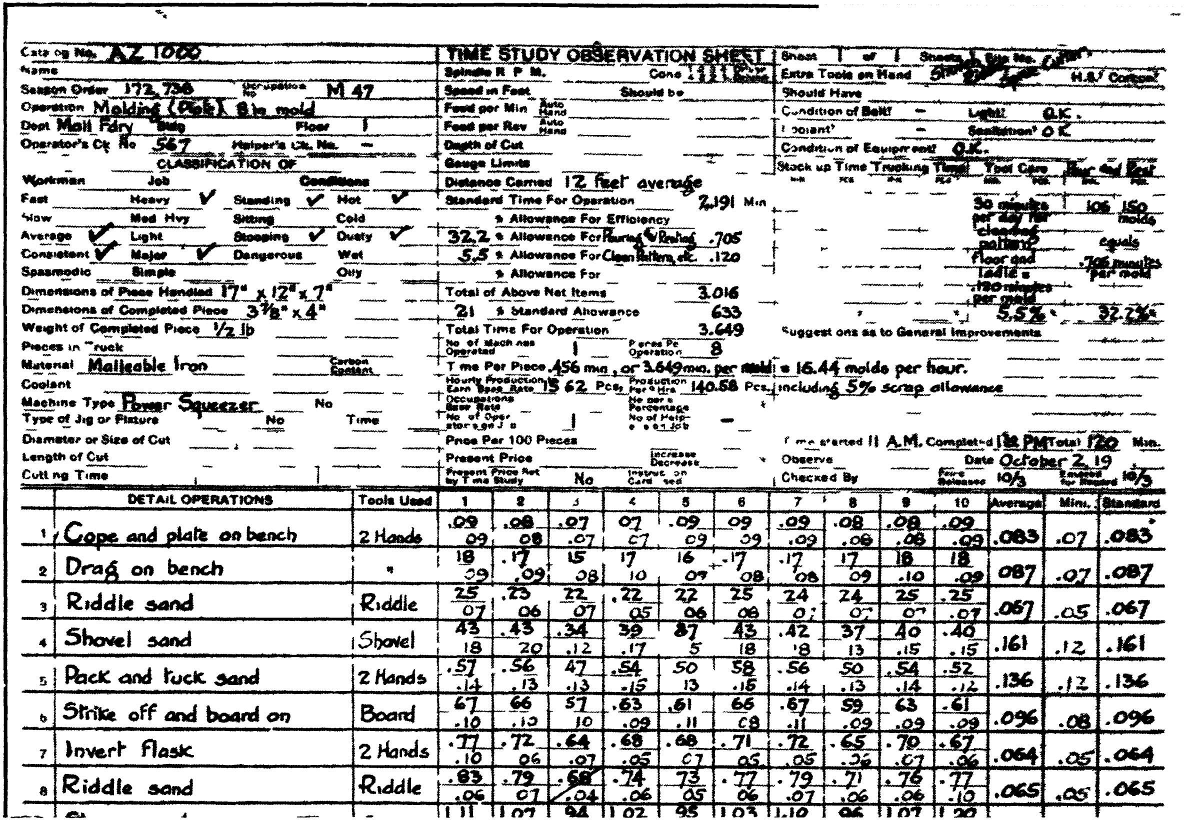
Term	Definition
Set tool	Means the time needed to bring the tool to its proper position by aid of scales, calipers, templates, gauges, stops, etc.
Return tool	Includes stopping of lathe where necessary and returning tool to starting point.
Piece from chuck to truck	Means loosening the work, taking out and dropping it in truck, box, barrel, or other receptacle.

This practice enables comparisons to be made with other studies in which some of the same elements are included. The difficulty of recording accurately times less than .03 or .04 of a minute may influence the length of elements selected.

The Observation Sheet Record.—Upon the observation sheet should be recorded all data pertaining to the task which have any bearing upon the time required. The conditions accepted as standard should prevail and be recorded in order that comparisons may be made if the time set is later questioned, or new studies made. Such data would include number of part, of operation, operator's name or number, department, description of machine or equipment used, list of tools needed, a record of lighting, ventilation, and sanitary conditions, together with suggestions. The method used should be clearly indicated and a sketch of the part included with explanatory notes, dimensions, and description of materials. The finished sheet should be self-explanatory at any future time to anyone reading it. Studies made in one plant may be used to govern operations in others, even in distant foreign countries. The time study observation sheet shown in Figure 119 provides an excellent example of good practice in this respect and should be carefully studied.

Methods of Taking Time.—When the observer is ready to begin taking actual times he should stand in a position which will enable him to see clearly what is being done and be free to concentrate on the work at hand. A position in front will tend to remind the operator that he is under observation and make him self-conscious and nervous. A position a few feet to one side and slightly to the rear, but within conversational distance, is preferable. There are four methods of timing more or less commonly used: viz., the (1) continuous method, (2) repetitive method, (3) accumulative method, and (4) cycle method.

The Continuous Method.—Figure 119 illustrates the continuous method of timing. The task having been divided into nineteen elements, the watch was started as the man started to work and as he completed each succeeding element the watch time was noted in column one opposite the element in question (the upper figure in the square). The time entered opposite the last element indicates the total time taken in doing the operation. In this case ten consecutive readings were taken, the watch being set back to zero at the beginning of each operation. Some observers prefer to secure the total elapsed time for all operations in one reading by letting the watch run continuously. The element times are readily secured (bottom figure in each square) by subtracting the watch reading at the beginning of an element from that at the completion. The time of



TIME STUDY OBSERVATION SHEET

Catalog No. AZ 1000
Name
Season Order 172,736 Occupation No. M 47
Operation Molding (Pole) 8 in mold
Dept Mall Fdry Bldg Floor 1
Operator's Ck No 567 Helper's Ck. No. –

CLASSIFICATION OF

Workman		Job		Conditions	
Fast		Heavy	✓	Standing ✓	Hot ✓
Slow		Med Hvy		Sitting	Cold
Average	✓	Light		Stooping ✓	Dusty ✓
Consistent	✓	Major	✓	Dangerous	Wet
Spasmodic		Simple			Oily

Dimensions of Piece Handled 17" x 12" x 7"
Dimensions of Completed Piece 3⅞" x 4"
Weight of Completed Piece ½ lb
Pieces in Truck
Material Malleable Iron Carbon Content
Coolant
Machine Type Power Squeezer No
Type of Jig or Fixture No Time
Diameter or Size of Cut
Length of Cut
Cutting Time

Spindle R P M. Cone
Speed in Feet Should be
Feed per Min Auto Hand
Feed per Rev Auto Hand
Depth of Cut
Gauge Limits
Distance Carried 12 feet average
Standard Time For Operation 2.191 Min
% Allowance For Efficiency
32.2 % Allowance For Pouring & Resting .705
5.5 % Allowance For Clean Pattern, etc. .120
% Allowance For
Total of Above Net Items 3.016
21 % Standard Allowance .633
Total Time For Operation 3.649
No. of Machines Operated 1 Pieces Per Operation 8
Time Per Piece .456 min., or 3.649 min. per mold = 16.44 molds per hour.
Hourly Production to Earn Base Rate 15.62 Pcs. Production Per 9 Hrs. 140.58 Pcs. including 5% scrap allowance
Occupations Base Rate No. per a Percentage
No. of Operators on Job 1 No of Helpers on Job –
Price Per 100 Pieces
Present Price Increase Decrease
Present Price Set by Time Study No Instruction Card Used

Sheet 1 of 1 Sheets Pattern No.
Extra Tools on Hand H.&J. Cotton
Should Have
Condition of Belt – Light? O.K.
Coolant? – Ventilation? O.K.
Condition of Equipment? O.K.
Stock up Time Trucking Time Tool Care Pour and Rest

30 minutes per day for cleaning pattern, floor and ladle = .110 minutes per mold 5.5%
106 150 molds equals .705 minutes per mold 32.2%

Suggestions as to General Improvements

Time started 11 A.M. Completed 1 P.M. Total 120 Min.
Observer Date October 2, 19
Checked By Piece Released 10/3 Entered for Record 10/5

	DETAIL OPERATIONS	Tools Used	1	2	3	4	5	6	7	8	9	10	Average	Mini.	Standard
1	Cope and plate on bench	2 Hands	.09 / .09	.08 / .08	.07 / .07	.07 / .07	.09 / .09	.09 / .09	.09 / .09	.08 / .08	.08 / .08	.09 / .09	.083	.07	.083
2	Drag on bench	"	.18 / .09	.17 / .09	.15 / .08	.17 / .10	.16 / .09	.17 / .08	.17 / .08	.17 / .09	.18 / .10	.18 / .09	.087	.07	.087
3	Riddle sand	Riddle	.25 / .07	.23 / .06	.22 / .07	.22 / .05	.22 / .06	.25 / .08	.24 / .07	.24 / .07	.25 / .07	.25 / .07	.067	.05	.067
4	Shovel sand	Shovel	.43 / .18	.43 / .20	.34 / .12	.39 / .17	.37 / .15	.43 / .18	.42 / .18	.37 / .13	.40 / .15	.40 / .15	.161	.12	.161
5	Pack and tuck sand	2 Hands	.57 / .14	.56 / .13	.47 / .13	.54 / .15	.50 / .13	.58 / .15	.56 / .14	.50 / .13	.54 / .14	.52 / .12	.136	.12	.136
6	Strike off and board on	Board	.67 / .10	.66 / .10	.57 / .10	.63 / .09	.61 / .11	.66 / .08	.67 / .11	.59 / .09	.63 / .09	.61 / .09	.096	.08	.096
7	Invert flask	2 Hands	.77 / .10	.72 / .06	.64 / .07	.68 / .05	.68 / .07	.71 / .05	.72 / .05	.65 / .06	.70 / .07	.67 / .06	.064	.05	.064
8	Riddle sand	Riddle	.83 / .06	.79 / .07	.68 / .04	.74 / .06	.73 / .05	.77 / .06	.79 / .07	.71 / .06	.76 / .06	.77 / .10	.065	.05	.065
			1.11	1.07	.94	1.02	.95	1.03	1.10	.96	1.07	1.20			

9	Shovel sand	Shovel	.28	.28	.26	.28	.22	.26	.31	.25	.31	.23	[illegible]	.22	[illegible]
10	Peen sand	"	1.26 / .15	1.22 / .15	1.08 / .14	1.19 / .17	1.08 / .13	1.17 / .14	1.26 / .16	1.11 / .15	1.22 / .15	1.17 / .17	.151	.13	.151
11	Strike off and board on	Board	1.40 / .14	1.32 / .10	1.18 / .10	1.30 / .11	1.20 / .12	1.30 / .13	1.38 / .12	1.24 / .13	1.37 / .15	1.30 / .13	.123	.10	.123
12	Press (Squeeze)	Power Squeezer	1.48 / .08	1.42 / .10	1.28 / .10	1.42 / .12	1.30 / .10	1.41 / .11	1.49 / .11	1.35 / .11	1.48 / .11	1.38 / .08	.102	.08	.102
13	Board off and cut sprue	Sprue Cutter	1.60 / .12	1.52 / .10	1.37 / .09	1.51 / .09	1.39 / .09	1.50 / .09	1.59 / .10	1.44 / .09	1.57 / .09	1.48 / .10	.096	.09	.096
14	Cope off	2 Hands	1.69 / .09	1.61 / .09	1.45 / .08	1.61 / .10	1.48 / .09	1.60 / .10	1.67 / .08	1.54 / .10	1.68 / .11	1.57 / .09	.093	.08	.093
15	Plate off	"	1.77 / .08	1.67 / .06	1.53 / .08	1.70 / .09	1.56 / .08	1.67 / .07	1.74 / .07	1.61 / .07	1.75 / .07	1.65 / .06	.075	.06	.075
16	Cope on (P=Patch Mold)	"	2.02 / P.25	1.80 / .13	1.64 / .11	1.92 / P.22	1.68 / .12	1.80 / .13	1.90 / .16	1.80 / .19	1.91 / .16	1.81 / .16	.163	.11	.163
17	Flask off	"	2.09 / .07	1.88 / .08	1.72 / .08	2.00 / .08	1.76 / .08	1.88 / .08	1.99 / .09	1.90 / .10	2.00 / .09	1.89 / .08	.083	.07	.083
18	Carry out ½ way (Average length of floor = 12 ft.) (A = Arrange floor)	"	2.28 / .19	2.05 / .17	1.89 / .17	2.30 / A .30	1.95 / .19	2.10 / .22	2.20 / .21	2.07 / .17	2.19 / .19	2.08 / .19	.200	.17	.200
19	Back to bench	Walk	2.34 / .06	2.12 / .07	1.96 / .07	2.39 / .09	2.04 / .09	2.19 / .09	2.27 / .07	2.17 / .10	2.26 / .07	2.15 / .07	.078	.06	.078
20	FATIGUE ALLOWANCE		SKETCH					FOUNDRY STANDARDS DATA					2.191	1.78	2.191
21	11.15 A.M. 13.0% 11.30 " 14.0%							Pieces in Mold? 8		Sprues? 1					
22								Length of Mold? 17"		Width? 12"					
23															
24	7 | 146.0% TOTAL 146.0%														
25	(Use 21% Allowance)														

This time study observation Sheet to be used for recording operations and establishing piece work rates.

SEE SKETCH ON OTHER SIDE

SYMBOLS: C — CLEAN CHIPS; X — STOCK UP OR COUNT; O — OIL OR COOLANT; Δ — F E; M — MACHINE CARE; S — SL; D — DF; < — TRUCKING; G — GAUGE; ☐ — GRIND TOOLS; T — TWIZZLE (Explain); P — PERSONAL; W — WAITING TIME

NOTE: During week of Nov. 15th one molder exceeded by 23% the production called for. During week of Oct 18th another molder, under the same shop conditions exceeded the same production figure (1562 molds) by only 8%. This demonstrates the difference in molders. The standard time and allowances granted under our plan of time study permit the average worker to produce at least 10% more than the output called for.

Figure 119 Observation Sheet Record of a Stop-Watch Study

completion of the preceding element is obviously the time of beginning of the one in question. Thus, for element number five in column one: $57 - 43 = 14$, or 14 hundredths of a minute.

The Repetitive Method.—The repetitive method utilizes the "snap-back" watch. At the completion of the first element of the task, the time is noted, and the watch snapped back to zero; from which point the hand instantly moves forward in measuring the time for the second element. This procedure is repeated for each element. It is not a good method for general use. It gives element times directly, but the need for noting the elapsed time and the time taken in snapping the watch back to zero results in "lost" time.

By using two watches as a unit, pressure on a bulb will stop one and start the other. In this way "lost time" between elements is avoided.

The Accumulative Method.—The accumulative method is used when the element times are very short: from .003 to .02 of a minute. According to the accumulative method, the observer uses two or more stop-watches, the number depending upon his ability and the length of unit times, and keeps each watch for a separate element. Assuming that the symbols of the elements are a, b, c, d, e, f, the first watch is started at the end of element f and stopped at the end of element a. Simultaneously with stopping the first watch, the second watch is started at the end of element a and stopped at the end of element b. Both readings are then entered on the time-study sheet, and both watches are thrown back to zero ready for repeating this routine, which process is repeated at least 20 times. Since the escapement of the watch allows the hand to make three forward moves each .01 of a minute, by stopping the hands the reading of the element may be recorded to .003 of a minute. The sum of the readings of the individual elements may be checked by taking an over-all study of the complete cycle.

The Cycle Method.—The cycle method of taking times also aids in getting short times accurately. If there are five elements in an operation, the five in sequence represent a cycle. Studies of as many cycles as there are elements are taken, omitting a different element each time as follows:

$$
\begin{array}{ll}
(1) & a + b + c + d \phantom{{}+e} = .10 \\
(2) & \phantom{a+{}} b + c + d + e = .09 \\
(3) & a + \phantom{b+{}} c + d + e = .07 \\
(4) & a + b + \phantom{c+{}} d + e = .10 \\
(5) & a + b + c + \phantom{d+{}} e = .08
\end{array}
$$

Adding, gives

(6) $4a + 4b + 4c + 4d + 4e = .44$ as the total time for four cycles.

Dividing equation (6) by 4 gives

(7) $a + b + c + d + e = .11$ as the operation time.

The time of element e is then secured by subtracting equation (1) from (7):

$$\begin{array}{r} a + b + c + d + e = .11 \\ \underline{a + b + c + d \qquad = .10} \\ e = .01 \end{array}$$

The time of element d is secured by subtracting equation (5) from (7):

$$\begin{array}{r} a + b + c + d + e = .11 \\ \underline{a + b + c + \qquad e = .08} \\ d = .03 \end{array}$$

And similarly for the other elements, disclosing the following values:

$$a = .02;\ b = .04;\ c = .01$$

Number of Observations.—The number of observations which it is advisable to take varies with the importance of the study, the total time required, possible variations in time required, the number of elements involved, and the amount and variety of extra work incidental to the operation. Enough must be taken to secure a true average of the time required. Extreme accuracy will not be so vital where the operation is performed infrequently. A task made up of a number of short elements with a total time of but a minute or less may merit the taking of as many as 100 studies, particularly if it is a standard task repeated day after day. Where the elements are few and take several or more minutes to perform and the operator is working uniformly, accuracy is possible with but a few studies. The probability of error is reduced when machine time rather than handling time is the larger percentage. Some time study observers believe that sufficient studies should be made to aggregate one hour of operation time. Thus, if the total time of the operation is only .60 of a minute, the study would be taken 100 times. If the operation consumed 1 minute, 60 studies would be made; if the total time amounted to 5 minutes, 12 studies would be considered sufficient; etc.

Analyzing the Data.—With job standardization work accomplished, the best method of doing the work ascertained, the worker trained in this method, and finally, studies made with a stop-watch yielding data of the time taken in doing each element of the task by a "first class" man, the observer is ready to analyze the data and determine upon the proper working time for the operation. Unless unusually complete information of all influencing factors is recorded on the data sheet, as in Figure 119, this analysis should be made by the observer while the conditions are fresh in his mind.

The time allowed will consist of two elements, base time plus allowance time. From the observed data the proper working time is determined for each element, and the total of these element times will give the selected working time, or base time for the operation. In Figure 119 the times selected for each element are given in the final column headed, "Standard." To the sum of these it is obviously necessary to add certain allowances to cover preparation time, inevitable delays, fatigue, machine maintenance, personal time, and perhaps make an allowance for the skill of the operator, etc.

Selecting Element Times.—There are several ways of selecting element times. All methods first eliminate abnormal times. No absolute general rule can be made regarding these, but time study men advocate that minimum or maximum isolated items 25% less or 30% greater, respectively, than an adjacent item should usually be rejected, and this is standard practice in many plants. From this point methods vary in choosing times for the several elements. They are known by the times they use, as (1) average, (2) minimum, (3) modal time, and (4) "good" time.

THE AVERAGE TIME METHOD. After eliminating abnormal times the average of the remaining times may be chosen, and this is a common practice when first class operators are studied. Its reasonableness appeals to the worker, and if the study is a "good" study, it should be fair in most cases. However, if the liability to error is in one direction only, it will not prove satisfactory.

THE MINIMUM TIME METHOD. To choose the minimum time in which each element is performed is to reduce the base time considerably below the average. It gives element times which may be considered as theoretical or ideal times, but which are impossible of attainment by the great body of average workers. Hence it is too severe and not fair to the workers. In Figure 119 the minimum time is 19% less than the average time.

THE MODAL TIME METHOD. The modal time, or most frequently recurring time may be chosen. Analyzing Figure 119 it will be noted that the time is less than the average time for twelve elements, greater in the case of six, and the same in one instance. The total of the modal times is but .016 of a minute less than the average; however, there is usually a greater difference in this direction. A time arrived at in this manner is one to which little objection can be taken, as it represents what is done in the majority of trials.

THE "GOOD" TIME METHOD. The practice of choosing "good" times as base times is not uncommon. The idea is that a time which is attained with reasonable frequency can with practice become an average time; and that the task set should be one requiring, on the average, improved performance. "Good" times are those appearing perhaps 15% to 30% of the total number. Their selection results in slightly lower times than the preceding method.

Deviation Ratios.—After eliminating abnormal readings for an element, the average and minimum times are determined. Dividing the former by the latter gives the deviation. The deviation ratio for the task is found by dividing the total of average element times by the total of the minimum column. It has been found that an average operator working fairly and consistently will have a deviation ratio of between 1.20 and 1.30. A lower ratio is exceptional and ratios that are much greater should be questioned. Whether or not a time study is "good" may be determined by applying this check. It is possible but not probable that a skilled operator, working at a uniform pace below his best, might bring about a low deviation. A high deviation ratio for an element may indicate some hindrance to a uniformly rapid rate of performance, which when disclosed can be eliminated. In Figure 119 the deviation ratio is 1.23, which is satisfactory.

Determining the Level of Performance.—The judgment of the observer is used to determine the degree of efficiency and effectiveness at which the operator is working. The observer will have in mind an acceptable standard of performance and rate the worker accordingly. He should be trained in this accomplishment so that approximately the same judgment will apply in all cases. This may result in a rating of 100% if the worker meets the standard, or 110%, or 90%. The base time would be corrected accordingly.

The Westinghouse Company has developed a technique to aid the observer in his judgment, which is used widely. They list the factors which influence productiveness, and descriptive words to denote the degree of each. Numerical values are assigned to each of these levels, as indicated in Table 11. A summation of the numerical values would give a figure, which when multiplied by the sum of the selected element times would give the base time (the net operating time allowed). To this are added the necessary allowance times to obtain the standard job time.

Determining Allowance Time.—As previously indicated an addition to the base time must be made to cover fatigue if present, unavoidable delays of all kinds, personal time, and sometimes preparation time. Allowances for tasks with which the worker is unfamiliar or which are

TABLE 11. PERFORMANCE-RATING TABLE

Skill			Effort		
+0.15 +0.13	A1 A2	Superskill	+0.13 +0.12	A1 A2	Killing
+0.11 +0.08	B1 B2	Excellent	+0.10 +0.08	B1 B2	Excellent
+0.06 +0.03	C1 C2	Good	+0.05 +0.02	C1 C2	Good
0.00	D	Average	0.00	D	Average
−0.05 −0.10	E1 E2	Fair	−0.04 −0.08	E1 E2	Fair
−0.16 −0.22	F1 F2	Poor	−0.12 −0.17	F1 F2	Poor

Conditions			Consistency		
+0.06	A	Ideal	+0.04	A	Perfect
+0.04	B	Excellent	+0.03	B	Excellent
+0.02	C	Good	+0.01	C	Good
0.00	D	Average	0.00	D	Average
−0.03	E	Fair	−0.02	E	Fair
−0.07	F	Poor	−0.04	F	Poor

performed infrequently need to be greater than for familiar, repetitive operations. Speed is gained slowly on new work.

The *fatigue allowance* should be sufficient to bring the standard time to the point where it is possible for the employee to maintain it year in and year out. Fortunately most jobs are now performed by methods and under working conditions which minimize fatigue, and a fatigue allowance is seldom needed. Where the work is severe, proper allowance should be determined for each individual job. Past practice has been faulty in this respect, in that allowances for this cause have been generally included in all job times. When necessary, fatigue allowances may be from 10% to 30% of the job time.

Delays may be avoidable or unavoidable. The former will not be included in job times. Likewise when unavoidable delays occur, as for machine repairs, the work may be temporarily discontinued. However, incidental interruptions do occur, and minor delays in the work are occasioned by tool breakage, machine delays, variations in material, and supervision. These should be reduced to a minimum, but full allowance made for those which necessarily occur, as determined by careful observation and study.

Machine delay allowances are the result of experience in the particular plant. They will vary with the type of equipment and the care with which it is maintained. Typical allowances are:

Machine time (power-feed)	5% to 10%
Machine time (hand-feed)	20% to 25%

These allowances are applied to machine time only.

There are unavoidable delays of a character which are not incident to the actual doing of the task itself, and coming outside of the operation cycle may not show up in stop-watch studies. Examples of such unavoidable delays are changing from one job to another, removing finished product, procuring new material, receiving instructions, adjusting conditions around working place, inspecting completed parts, and the like. Unavoidable delays are usually cared for through adding arbitrary allowances. Some use a factor of 25% of preparation time. These allowances are often a very small proportion of time for the whole job, and may be of little practical value other than their effect upon mental attitudes of the operator. On automatic work they are often of importance.

Personal time allowances are usually from 3% to 5%; although some plants plan on 7½ hours of productive time in an 8-hour working day.

Preparation time necessarily varies with the task and with the industry. It may be cared for by considering the preparation time as a separate

element of the task, when preparation is necessary preceding each operation, and is of relatively short duration. When preparation is in itself a major operation and the time required is independent of the resulting production, as in the case of setting up automatic machines, or when it takes considerable time and is of infrequent occurrence, it is best considered as a separate operation. An example of this would be the adjustment of a paper machine for a particular grade and weight of paper. In other cases the preparation time may be distributed as an addition to the unit production time. This is feasible when the output following preparation is a definite amount, so that each unit may bear its proper amount of burden.

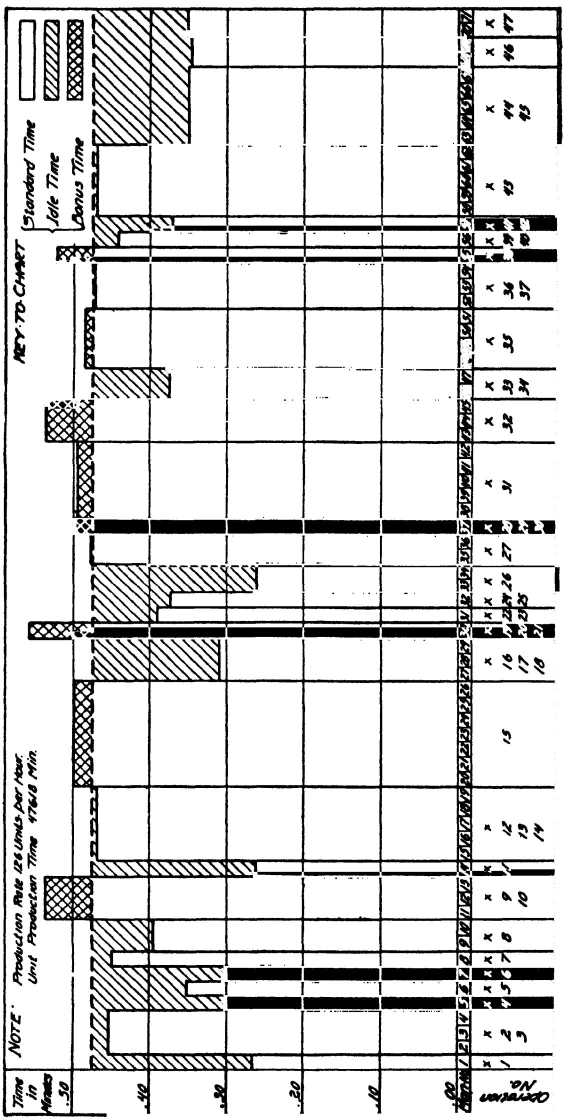
Much of the criticism and ridicule which has been leveled at time study has been due to the arbitrary and often absurd allowances added to base times. The worker has little confidence in the reasonableness or fairness of any method which measures his motions to .02 of a minute, or less, and then admits the uncertainty of results by lump-sum allowances of 30 to 50 or even 100% of the actual time of doing the operation. Allowance times should be carefully determined, and separately applied, and the reasons and basis for each of them should be made known to the workers.

Reference to Figure 119 shows allowances for the molding operation studied as follows:

32.2% allowance for pouring and resting.
5.5% allowance for cleaning pattern, etc.
21.0% allowance for fatigue.

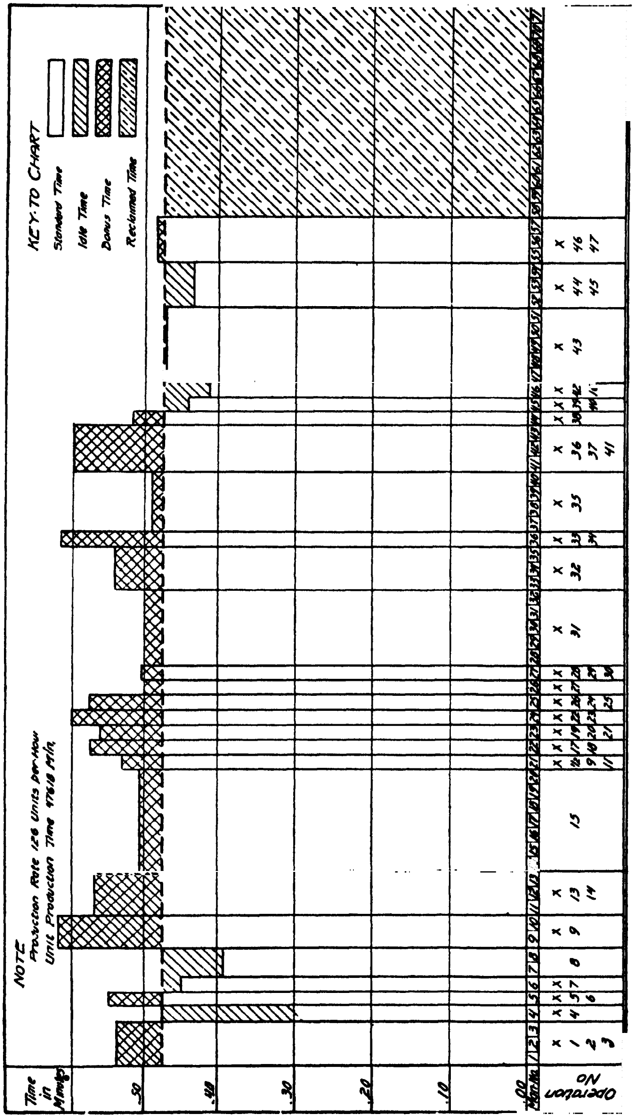
In this study the worker is indicated to be "average," and the sum of the average element times is taken as the standard time. The first two allowances are considered necessary if the worker is to maintain production at the rate set. The third, or fatigue allowance, is not so considered, although no further allowance is made for personal needs. It is the idea in this plant that a good worker may utilize the standard 20% allowance time for fatigue in increasing his earnings if he so wishes.

Time Studies on Automatic Machinery.—The output of automatic machinery could be readily calculated, if the speed of operation is known, if it were not for delays due to replenishing materials, changing tools, making minor adjustments, and other causes. Hence in taking time studies of this type of equipment the cause and time of all interruptions to continuous, uniformly rapid operation must be noted over a sufficiently long time to make sure that none has escaped notice. When known they may be eliminated or proper allowances made. The record of actual out-



(Courtesy of T. R. Hough and W. C. Hasselhorn)

Figure 120. Original Nonstandardized Operation Sequence and Task Assignments of Group Production Operations



(Courtesy of T. R. Hough and W. C. Hasselhorn)

Figure 121. Standardized Operation Sequence and Task Assignments of Group Production Operations

put over the period of study may often be obtained by use of automatic counters. From the data obtained a factor may be derived which when applied to the theoretical capacity of the machine will give its normal output.

Group Operation Studies.—Studies of group production in progressive manufacturing operations are conducted essentially the same as individual operation studies. First, a thorough job of industrial engineering is followed by training of selected workers, and finally by stopwatch studies on individual elements of the task. The accompanying chart (Figure 120) shows the results of a preliminary study of 47 operations, performed by a group of 71 men. Presented graphically the amount of time worked by each, the division of the task among the group, and bonus earnings are clearly shown. Following a careful study the work was rearranged and divided as indicated in Figure 121. Much time was reclaimed, as indicated by the reduction in numbers of the group, and most of the group enabled to earn a bonus.

CHAPTER 24

MOTION AND TIME STUDY—PUTTING STANDARDIZED METHODS INTO PRACTICE

Synthetic Time Studies.—In the last chapter the method of determining operation times from stop-watch studies was explained. Previously it was indicated that it was possible to obtain times from micromotion films when these were utilized. A third method has been used very successfully by certain motion and time analysts to obtain standard task times without the necessity of observing each particular job. These are known as synthetic time studies inasmuch as they are built up in the office from data previously obtained in other studies. To make these possible standardized conditions must prevail.

Many individual jobs have sub-operations or elements which are common to other jobs. With this idea in mind it is the practice in some shops to study all the elements involved in doing work. A proper working time for each basic element is determined. Data of this kind may be obtained partly from machine tool builders, from available stop-watch studies, and from the analysis of fundamental motions involved in performing the work. These may be utilized to prepare charts, diagrams, and formulas by means of which any job time within the range of the work studied may be determined. This technique is more costly to begin with and may be slower in yielding individual job times, but it is economical in the long run.

Preparation and Use of Time Standards.—Time studies of individual operations may be a source of data for element times used in formulating these time standards. When the preparation of time standards is the immediate objective rather than individual operation time studies, the procedure outlined in the preceding chapter is varied somewhat.

It is desirable to analyze and study the work performed with the idea of preparing a standard list of elements which enter into it. Attention is then centered upon gathering data pertaining to these element times when and where possible. Values as determined may be expressed in tables, charts, and formulas. As an illustration, one element of foundry moulding operations for floor moulding is, "Level floor before setting board." Numerous studies provide time data for this element which permits a chart to be prepared as in Figure 122. From this chart the

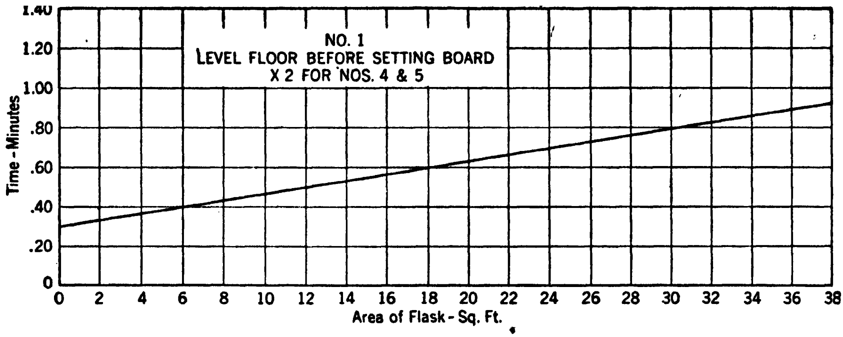


Figure 122. Example of Graph Showing Proper Element Time

time for this element, using various flask sizes is readily determined. Similarly for other elements. Times can be set without going into the shop and with the certainty that results will be equable, onc with another, and constant regardless of the time at which they are set. While stop-watch studies are usually good, it is not possible to eliminate a certain amount of inconsistency in task time. The well-being of the operator, the time of day, working conditions, or judgment of the observer may influence the time recorded for an individual study. These variations are eliminated by the compilation of standard data. However, to obtain suitable values for the various elements requires the closest observation, a large number of data, and a thorough familiarity with the subject in hand.

The use of standards for determining operation times assures the maintenance of operating conditions as established, for with any slackness the times set will not be attainable and will call for an investigation leading to a correction of them. The use of standard data also sets times on a basis of the conditions and methods that ought to prevail, which may not be so true in the case of individual operation studies unless the observer is unusually alert and thorough in his work. Task times set from time standards will be more consistent than those established from individual time studies.

Interpolation and Extrapolation of Standard Times.—When operations to be performed are the same except for variation in weight or size of the material worked upon, the distance walked, the length of haul, or the extent of the work to be done (as number of holes to be drilled in a part), it may not be necessary to take individual time studies of every operation. For instance, several different sizes may be studied and the times plotted on cross-section paper, using time intervals as ordinates and sizes as abscissae (as in Figure 122). By drawing a curve through

and beyond these points the time required for sizes other than those studied will be indicated. At points where some change in equipment or method is necessitated due to size or weight variations, for example, there is likely to be a sudden break in the curve, and these points must be studied carefully. If the curve is of irregular shape for the point plotted it will not prove dependable in indicating other operation times.

Time Standards for Fundamental Motions.—The Time and Motion Study Group of the Industrial Management Society, Chicago, suggests the following technique as a practical method of motion analysis and the determination of time data which (1) is simple enough that it can be taught to and practiced by the operator on the job; (2) will produce consistent piece rates which the operator can check; and (3) enables the operator to work out his own improvements.

SCOPE. The time data in this plan apply under the following conditions:

(a) The work is done while the operator is seated.
(b) The work is performed within the "normal grasp areas."
(c) Weights handled do not exceed 2 pounds.

DESCRIPTION OF PLAN. The task studied employs eight motion elements as follows:

TE (Transport empty) The motion of moving the empty hand from one place to another.
G (Grasp) The motion of closing the fingers on an object.
TL (Transport loaded) The motion of transporting an object from one place to another.
P (Position) The motion of placing an object in a predetermined relationship with another object.
R (Release) The motion of opening the fingers to release an object.
I (Inspect) The eye motion of moving to and focusing upon a certain point. (This element is seldom used in the ordinary production operation. It covers the actual inspection time when both hands are idle or are doing ineffective work.)
D (Delay) This is not a motion but is employed for the purpose of balancing the motions of one hand with the motions of the other hand. Delays are of two general types:

1. Where the hand is idle or waiting or is doing ineffective work such as holding.
2. When the other hand is doing work which requires visual or conscious direction.

The proportion of "D" items in the analysis indicates the extent to which the method is inefficient.

M (Machine time) This is the chargeable time for the machine cycle where the hands must wait until the machine or tool has completed its work.

TIME VALUE. The time values for the above elements are as follows:

Motion	Time in Minutes
TE	.005
G	.002
TL	.005
P	.005
R	.002
D	Give time value of opposite motion.
M	Time must be calculated for each operation.

APPLICATION OF TIME VALUES.

1. The motion elements are divided into two groups:

(a) Manual elements

TE	.005
TL	.005
R	.002

It will be noted that these elements are of such nature that they do not ordinarily require conscious mental direction to perform them.

(b) "Mental" elements

G	.002
P	.005

These elements usually require conscious direction by the mind and eye. This conscious effort can be eliminated from the "grasp" by having the parts or tools prepositioned and in fixed locations, and from the "position" by the use of mechanical guides.

2. The elements are applied by listing them as they occur in the operation. An 8½″ x 11″ lined sheet may be ruled and headed as follows to serve as a motion analysis form.

L. H.			*R. H.*		
Motion Element	Description	Time	Motion Element	Description	Time

3. As each element is listed in one column a corresponding entry must be made in the adjacent column, thereby "balancing" the work of the two hands. In balancing these motions one important rule must be followed.

Rule: Manual motions can be balanced with each other and with DELAY. Mental motions can be balanced only with DELAY.

Examples:

BALANCING MANUAL MOTIONS

	L. H.			*R. H.*	
TE	to part	.005	TE	to part	.005
	or				
TL	part to fixture	.005	D	wait on L. H.	.005

BALANCING MENTAL MOTIONS

	L. H.			*R. H.*	
G	part	.002	D	wait on L. H.	.002
	or				
D	wait on R. H.	.005	P	part in fixture	.005

The explanation of this rule is that conscious attention cannot be given to more than one point at a given time. Experiments have shown that in grasping parts from a haphazard pile of parts with both hands working simultaneously, one hand waits until the other has grasped the part before it starts its motion. The same is generally true of "position."

4. An example of the application of the time values may be shown by an operation on a punch press.

The examples cover the manual motions involved in inserting small individual parts into a punch press die with tweezers. One part at a time is picked up with the left hand and placed in tweezers held in the right hand which inserts the part in the die, releases the part and withdraws the tweezers while the foot presses the treadle to operate the press. The parts are automatically ejected by an air blast. The manual elements are performed simultaneously with the operation of the press, therefore, the time for the machine cycle is not chargeable to the time required to perform the operation. The machine is equipped with a swinging safety guard.

Example 1: Parts which do not require positioning in the die such as in a bumping operation.

Motion Element	*L. H.* Description	Time in Minutes	Motion Element	*R. H.* Description	Time in Minutes
TE	to part	.005	TL	part in tweezers to die	.005
G	to part	.002	D	wait on L. H.	.002
D	....	.002	R	part	.002
TL	part to R. H.	.005	RE	tweezers to L. H...	.005
D	....	.002	G	part in tweezers..	.002
R	part	.002	D	wait on L. H......	.002
		.018			.018

Example 2: Washer-shaped parts. Located over one round pilot or into a round nest.

L. H.

Motion Element	Description	Time in Minutes
TE	to part	.005
G	part	.002
D	wait on R. H.	.005
D	wait on R. H.	.002
TL	part to R. H.	.005
D	wait on R. H.	.002
R	part	.002
		.023

R. H.

Motion Element	Description	Time in Minutes
TL	part in tweezers to die	.005
D	wait on L. H.	.002
P	part in die	.005
R	part	.002
TE	tweezers to L. H...	.005
G	part in tweezers ..	.002
D	wait on L. H.	.002
		.023

Example 3: Odd-shaped parts. Located over more than one pilot or over one pilot and between two pins. Any part requiring more than usual difficulty in positioning.

L. H.

Motion Element	Description	Time in Minutes
TE	to part	.005
G	to part	.002
D	wait on R. H.	.005
D	wait on R. H.	.005
D	wait on R. H.	.002
TL	part to R. H.	.005
D	wait on R. H.	.002
R	part	.002
		.028

R. H.

Motion Element	Description	Time in Minutes
TL	part in tweezers to die	.005
D	wait on L. H.	.002
P	one end of part...	.005
P	other end of part..	.005
R	part	.002
TE	tweezers to L. H..	.005
G	part in tweezers ..	.002
D	wait on L. H.	.002
		.028

The total standard time per part can be computed by adding allowances to the above values for periodic gauging of parts, handling containers, etc. The result will be a time standard for punch press operations of this type which is of universal application.

Charts, tables, and formulas may also be developed from these analyses, so that a mathematical calculation, consistent time values for given classes of work may be determined in much less time than by individual time study methods.

Instruction Cards.—Written instructions for employees in the form of standard practice instructions were discussed in the chapter on Standardization and Simplification. In Chapter 22 process charts as used for instruction purposes resulting from motion analyses were presented. Instruction cards mav also be prepared and used advantageously follow-

INSTRUCTION CARD

Cat. No.	Complete Description of Operation
A Z 1000	Molding (Plate) 8 in mold.

Number of Men on Job	Machine No.	Tools Used	No. of Tools or Drills Operator Should Have	Material	Spindle R. P. M.	Speed in Feet / Feed per Rev.	Depth of Cut / Gauge Limits
1		Shovel Riddle etc. Carbon? H.S.?		-	Cone 1234 Driver 4321 Driven		

ELEMENT	DETAIL OF ELEMENTS AND INSTRUCTIONS TO OPERATORS	TOOLS USED	MINUTES TO COMPLETE
1	Cope and plate on bench	2 Hands	.083
2	Drag on bench	"	.087
3	Riddle sand	Riddle	.067
4	Shovel sand	Shovel	.161
5	Pack and tuck sand	2 Hands	.136
6	Strike off and board on	Board	.096
7	Invert flask	2 Hands	.064
8	Riddle sand	Riddle	.065
9	Shovel sand	Shovel	.268
10	Peen sand	"	.151
11	Strike off and board on	Board	.123
12	Press (Squeeze)	Squeezer.	.102
13	Board off and cut sprue	Cutter	.096
14	Cope off	2 Hands	.093
15	Plate off	"	.075
16	Cope on (patch mold, 1 in 10)	"	.163
17	Flask off	"	.083
18	Carry out (Average length 12 ft)	"	.200
19	Back to bench.	Walk	.078
20			2.191
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
	TOTAL TIME		

Machines on which proper speed and feed can be obtained.

ENGINEERING DEPARTMENT

This form to be used for recording data from time study sheet and is sent to head of department as complete instructions showing method and order of operations.

Figure 123. Instruction Card

ing many stop-watch studies. An instruction card should inform the worker regarding the task in every particular, answer all questions of "what to do and how to do it," and give complete information of equipment, tools, and materials used. Sketches or drawings are frequently helpful in showing arrangements or set-ups and in making instructions clear.

Figure 123 illustrates an instruction card prepared from data supplied by the stop-watch study in Figure 119, pages 396–397. It shows the elements of the operation in the sequence in which they are to be performed and the time allowed for doing each. The equipment and tools required are listed, and there is space for including data as to speed, feed, depth of cut, and the particular machine to be used in the case of machine operations. The method of performance is made clear step by step. On the reverse side of the instruction card is supplied the rate per 100 pieces, with allowance times and all computations leading up to the determination of standard hourly production, so the worker can see for himself how the task was determined. (See Figure 124.)

Value of Instruction Cards.—Instruction cards had their beginning in the metal trades industry. Frederick W. Taylor in his great paper, "On the Art of Cutting Metals," shows that every metal-cutting operation "involves the solution of an intricate mathematical problem in which the effect of twelve independent variables must be determined."[1] The impossibility of a machinist solving such problems is apparent; but the proper feeds, speeds, depth of cut, tools, etc., to use can be determined for each operation and the information supplied to the workman. Instruction cards separate planning from performance in a very effective way. They are now used generally throughout industry for a wide variety of tasks from washing windows to the operation of intricate machinery. They simplify the giving of instructions and training and the issuing of orders; they provide permanent records of standard conditions and best methods, preserving good ideas and checking tendencies to backslide. Used with a "tickler" system, instruction cards assure regularity and thoroughness in the doing of occasional jobs. More important still, they may bring within the range of the worker tasks which he otherwise could not per-

[1] "On the Art of Cutting Metals," by Frederick W. Taylor, p. 32. The variables as named by Taylor are as follows: (a) the quality of the metal which is to be cut; (b) the diameter of the work; (c) the depth of the cut; (d) the thickness of the shaving; (e) the elasticity of the work and of the tool; (f) the shape or contour of the cutting edge of the tool, together with its clearance and lip angles; (g) the chemical composition of the steel from which the tool is made, and the heat treatment of the tool; (h) whether a copious stream of water or other cooling medium is used on the tool; (j) the duration of the cut, i.e., the time which a tool must last under pressure of the shaving without being reground; (k) the pressure of the chip or shaving upon the tool; (l) the changes of speed and feed possible in the lathe; (m) the pulling and feeding power of the lathe.

PIECE WORK PRICE CARD

Catalogue No. A Z 1000

Operator's Check No. 567

Dept. Mall. Fdry. Bldg. 30B Floor 1

Operation Molding (Plate) 8 in mold

Standard Time for Operation 2.191 Min.

32.2 % Allowance for Pouring & resting .705 Min.

5.5 % Allowance for Clean pattern, etc. .120 Min.

% Allowance for Min.

21 % Added for Efficiency .633 Min.

Total Time for Operation 3.649 Min.

No. of Machines Man Operates 1 Units per Operation 8 in mold

Unit Time .456 min. or 3.649 min per mold Min.

Hourly Production at Efficiency Worked 16.44 molds Hourly Production at % Efficiency Pcs.

or 15.62 molds, deducting 5% for scrap.

Suggestions as to General Improvements

Price per 100 pieces $ ---

Season Order 172,738

Old Price $ ---

This price is based upon performance of operating under conditions found when time study was made, and will be in force as long as the elements outlined on reverse side of this card are followed.

When work cannot be done as shown on reverse side hereof, or if job is changed to another machine having a different stroke or cycle, this price is not effective, and Engineering Department must be notified at once.

Observer Maasberg Date 10/2/ Price released Date 10/3 Original card delivered 10/3 Date Approved L.A. Heyn Date 10/3

(OVER)

This form to be used by Engineering Department in advising departments of piece work rates established by means of time study.

Figure 124. Piece-Work Price Card

form, as in metal cutting. In repetitive work, instruction cards are referred to less frequently as the worker becomes familiar with the task, but they are no less valuable as a record of methods and standards to be maintained. They are often helpful in the training of new workers. For jobs not so frequently repeated they assure proper procedure and make certain the attainment of quality and quantity standards without delay or experiment.

Written Instructions Benefit Workers.—Written instructions take to all the workers the best known method of accomplishment. They do not prevent the worker from exercising his ingenuity and skill in effecting improvements; in fact, worthwhile incentives should be offered to this end in the form of substantial money rewards. However, they do prevent any retrogression and give all the benefit of innovations adopted. In this way they enable each person to benefit to the maximum from his efforts. They do for him what he would do for himself if he possessed the wide range of intelligence, the time and command of facilities necessary for the compilation of the information. The methods or procedure outlined are logically the easy, natural methods and lead to perfection of accomplishment. The worker is no more degraded or made an automaton than any artist is when he strives for perfection of technique as indispensable to the best expression of his art.

The practice of submitting to the worker complete data and information in written form provides every incentive for fair and accurate work by the motion and time study department. Individual element times offer an opportunity for a detailed check which the worker will make. Allowance times must stand the test of the worker's experience. In the past concealment of data provided a way for imposing unfair times upon the workers, but management defeated its own aims, for the workers cannot be fooled. With all the "cards on the table" there can be no jokers in motion and time study. What is right is apparent to all concerned.

Motion and Time Study Makes Wage Policy Effective.—For any wage policy to be effective rates must be equable and correctly set. Motion and time study assures this. Past unfairness in the practice of rate cutting makes it advisable to guarantee the permanence of wage rates to the workers, and a statement to this effect may appear on the instruction card. The guaranty is best made subject only to changes in operating conditions, equipment or in the task itself. In Figure 124 the rate is guaranteed so long as "the elements outlined" are followed, hence the worker may produce the maximum quantities possible without fear of being penalized.

Training in the Established Method.—A task may resolve itself into a natural sequence of elements which are necessarily performed in a given way because of the equipment used. In these many cases the method, motions, and movements of the worker are largely regulated by the arrangements. The training required is principally limited to practice in the use of the equipment. In order not to repress the worker's individuality or ingenuity and possibly make him feel that he is being reduced to a machine, stress should be placed upon exactness in manner of performance only as necessary to aid him in getting results. Some firms make no effort to train the worker in manner of performance unless he requests instruction, which he will usually do if he has difficulty in attaining the standard.

For many operations, exacting training in motion and rhythm is imperative if high task standards are to be achieved. Merely supplying the worker with an instruction card outlining the manner of performance will not suffice. If the method is different from past practice or if it is complex, it will involve teaching him new habits and breaking old ones, a task requiring infinite patience and tact. Before this is attempted the worker should have a clear conception of the new method and realize that it is easier, quicker, and more profitable to him. Then the instructor must guide him step by step in doing the job the new way, repeating the process until the worker is thoroughly familiar with each elementary detail of the operation. The instructor must not become discouraged or impatient with the worker's slowness to learn the new technique. Ingrained habits are hard to change, and the acquirement of skill a slow and tedious process for many. The workman will not learn the job by observation alone, but as a student is taught to write, will need to be drilled in every movement. The individual who qualifies for the task with some difficulty will likely be content to remain at that task, whereas the more easily trained worker capable of going higher will soon leave a vacancy. The beginner who fails to "get the hang" of the job will also leave. Proper training brings low costs, decreases expensive labor turnover, and eliminates waste incident to poor craftsmanship.

Production Time Studies.—A production time study is a study of a job under normal operating conditions over a period sufficiently long to disclose any machine and equipment difficulties or deficiencies, unnecessary delays, waste of time, unsatisfactory environment, wrong methods, and the cumulative effect of any fatigue. Inability of an operator to consistently achieve the standard set by the time study observer through no apparent fault of his own, suggests possible error in the original study. A production time study may be made, preferably with the use of a stop-

watch over an entire working day or even longer, to disclose the reasons for failure.

Figure 125 is an example of a production time study where the observer simply noted the various activities of the operator and the time taken for each, together with the completion times of each operation. The data are presented graphically, and in practice, different-colored lead pencils are used to denote the several classes of time recorded. At a glance they give a clear picture of the use of the time. This is summarized in minutes and percentages at the bottom of the chart together with information of the number of pieces produced and productive time per piece. As the output was 213 pieces a good check is afforded on the correctness of the original time study (shown in Figure 119), and the reasonableness of allowances made. A more refined method of making production time studies is to let the watch run continuously, taking down element times as well as the time of interruptions, delays, and time taken in doing the various classes of work. This is more laborious but provides additional data for detecting discrepancies and variation in the operator's methods, and will possibly enable the observer to make immediate corrections. Production time studies are obviously the "acid" test for time study work.

Carefully made time studies will not often be found in error, but the willingness of the management to subject them to test under working conditions should do much to further the faith of the workers in their reliability. A production time study checks the management's success in maintaining standards and discloses any overlooked hindrances to the doing of the task, as well as revealing deficiencies and delinquencies of the operator. The results are conclusive and offer little opportunity for argument.

The Motion and Time Study Division.—The work of the time study division includes: (1) job standardization and motion analysis preliminary to time studies; (2) taking time studies; (3) analyzing the data and fixing of base times; (4) establishing proper time allowances; (5) preparation of instruction cards and training of the workers; (6) making production time studies on completed work; and (7) job evaluation. Also there will be need for constant cooperation between this department and the operating departments with respect to improvements in equipment, tools, and procedure which motion and time study constantly suggests.

In establishing a new department it is essential to engage competent individuals and to exercise the utmost thoroughness in doing the work. The extent of the organization needed will vary with the character and extent of the manufacturing operations. Ordinarily it will take one man sev-

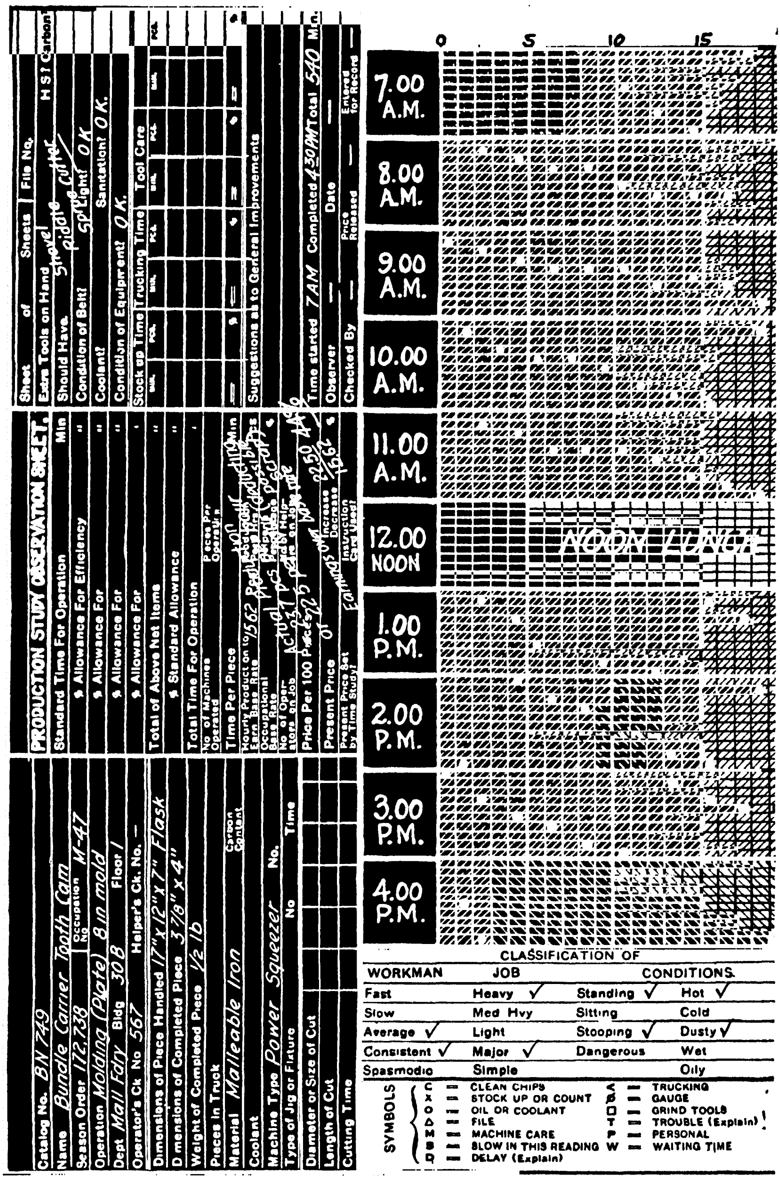
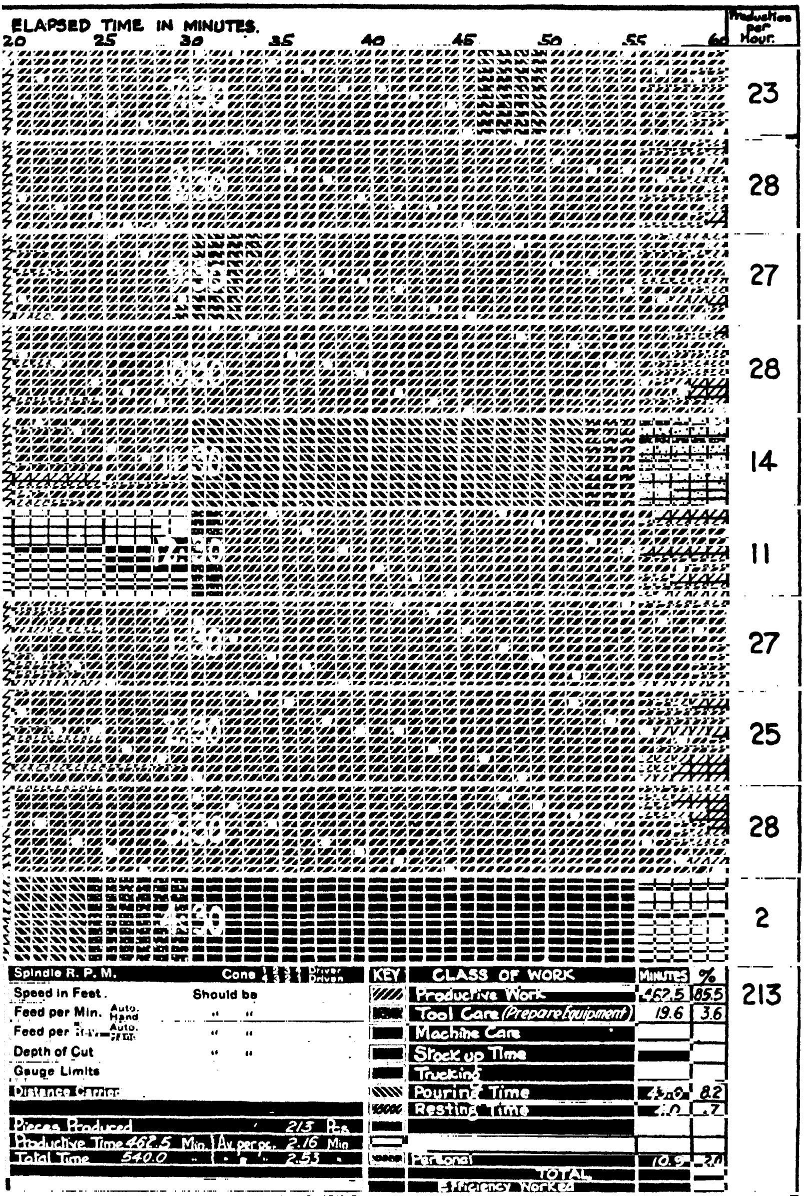


Figure 125. A Production



Time Study Sheet

eral months even in a small plant to complete the various steps in the work, to train the workers in the new methods, and to win acceptance of the standards set. Then, if the shop is small and the operations of a fixed character, outside aid may be utilized from time to time in keeping the work up to date. In most plants, however, there is sufficient work to be done in making new studies, revising obsolete rates, and effecting improvements to warrant the employment of at least one man full time.

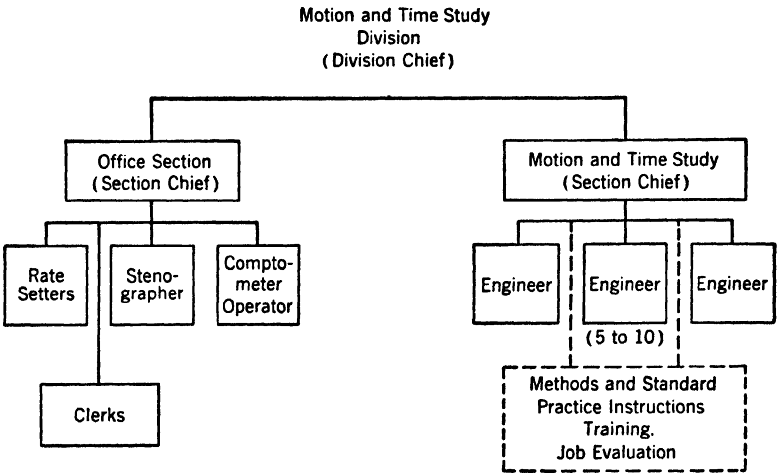


Figure 126. Organization of a Motion and Time Study Division

Best results are obtained by individuals thoroughly conversant with the shop and its personnel.

A larger organization would include a division chief, section chiefs, motion and time study men, and a staff of office workers. With the exception of the latter group, these men would be classed as industrial engineers, and qualified by education, training, and experience for this work. The division chief should possess a thorough knowledge of manufacturing and of costs, and be able to coordinate his work with that of the personnel department. He will need to organize and plan the work of the division, appreciate the possibility of developing standards, formulas, and charts in order to simplify the work and make the results more accurate, and to prepare standard practice manuals for the guidance of his staff. All methods and rates should have his approval before being put into effect.

The clerical staff will comprise a comptometer operator, stenographers, piece rate clerks, and clerks for making charts, keeping records, filing,

and miscellaneous work. A section chief can direct the work of from five to ten engineers. When making time studies each man will turn in the observation sheets to the office section for all purely arithmetical computations. The sheets are then turned back to the observer who determines base times and allowances and sets the standard times for each operation. He will also check the preparation of instruction cards. Where training is provided for the workers this may be a part of the engineer's task, or be taken care of by special instructors. The rate setters convert time standards into money values as piece rate prices.

CHAPTER 25

WAGES—THE PROBLEM OF EQUITABLE COMPENSATION

Payment of Labor Under Different Economic Systems.—Under slavery and feudalism little attention was given to individual production, and as a consequence labor was poorly paid. Payment for work was usually made in kind, and the standard of living was low. A system of wages had scarcely developed. It was not until the emergence of capitalism and the recognition of the laborer's right to change his occupation that wages became the usual mode of compensation.

The economic agents of production, land, capital, labor, and management, all must receive their remuneration from the value of the products produced. In an attempt to have labor, rather than the capitalist, own and distribute the final product several experiments in communal living have been made. Among many in the United States, and one with the most favorable prospects, was that of the Amana Society in Iowa, with its 26,000 acres of finest farm land, many industries, and seven villages housing about 1,800 people.[1] Amana was backed by a powerful religious force, the Amish faith, with a tradition of communal living. The community was almost self-sustaining and could have lived comfortably. Seven generations lived in communism at Amana. Traits which weakened the solidarity of the group were laziness, acquisitiveness, and desire for individuality—common human characteristics. Recently reorganized as a corporation, with wage payments for work done, the cost of outside farm labor alone decreased $60,000 a season.

The Russian experiment in communism, with its motto of "Work according to one's ability and receive according to one's needs" failed for the same reasons. In order to secure a high production from the workers it soon became necessary to reestablish the individual wage system based on productivity.

So far wages have proved the greatest incentive for productivity that has been devised—greater than the whip of the slave overseer and greater than the hope of a better group life held out by communism. The individual looks to his own immediate advantage and governs his efforts

[1] "Prophecy at Amana," by Arthur H. Carhart, *The Rotarian*, Vol. 49, No. 5.

accordingly. The capitalistic incentives of wages, bonuses and profits have been the spur which has brought industry to its present state of high efficiency.

The Reason for Different Wage Plans.—For labor in general wages are the prime motive force generating productive activity, and without an adequate and satisfactory basic wage other efforts of management to increase productive efficiency and promote harmonious relations with the workers—usually expressed through personnel department activities—will prove futile. Of no less importance than the amount of wages is the method of payment used. The human equation accounts for the numerous wage systems advocated, with their various psychological appeals to the intelligence and emotions of the workers.

With the greater use of capital goods in the form of machinery and other equipment as an aid to production, overhead costs have steadily mounted. Hence lost time has assumed a much greater importance than formerly, and any incentive that will lead to greater output results in double savings. Designers of wage plans have exercised considerable ingenuity in developing schemes that appeal to different classes of workers under various conditions; all with the purpose of increasing production and thus reducing unit costs.

Basic Wage Theory.—Out of a number of theories that have been advanced to explain the amount of wages paid to laborers two are now held in greatest respect by most economists. These are the marginal productivity theory and the bargaining theory. Briefly stated, the marginal productivity theory contends that the wage level of a certain occupation depends upon the productivity of the marginal laborer when there exists a perfect freedom of contract and substitution of workers. On the other hand, the bargaining theory holds that wages result from bargaining between employers and employees either individually or collectively. If labor is strong in its bargaining power, wages will be at a high level, while if labor is relatively weak in this respect, wages will be low. It seems that the bargaining theory explains the short range period more satisfactorily under modern conditions, while over the longer range the marginal productivity theory will prevail.

It is certain that in the ultimate analysis wages must be paid out of the goods produced, and payments cannot continue in excess of the value added by labor. Anticipating the public's needs business men utilize capital and labor in the most advantageous proportions to satisfy the effective demand, seeking to profit by the managerial effort put forth. Since wages are advanced to labor before the goods are sold, errors in judgment of the worth of labor may occur. On account of this and for

other reasons labor may be over or under paid for a short period. Over a longer time general wages cannot fall below the amount necessary to maintain a minimum standard of living and they cannot rise above the amount earned. Within these limits wages will fluctuate depending upon the available supply of labor, economic conditions, buying power, individual skills, and other factors.

Monetary and Real Wages.—Under normal conditions labor seems to be concerned only with the amount of money received as wages, usually so much per hour. Actually the monetary wage is not nearly so significant as the real wage—the amount of goods and services that can be purchased by the monetary wage. When economists speak of wages and wage levels they have in mind the real wage. At a particular time monetary wages may be high, but if the price of commodities and other things that the laborers consume has risen to a greater extent, the real wages would be low. Labor leaders have come to a greater appreciation of the significance of the real wage, but because of the psychological effect of monetary wages most wage controversies stress only the amount of money received.

Just Wages.—To a considerable extent we have horizontal strata in our social organization, and to the extent that the wages paid enable individuals to satisfy the living standards of their group, the majority will be content. A wage level which affects home life adversely and hinders civic progress and development will not be a satisfactory wage according to our standards. Just wages may be termed those which are commensurate with the service performed, but these are difficult if not impossible to determine. The value of the contribution made by each person involved in the making and marketing of a pair of shoes illustrates this.

Various organizations have defined "minimum standards of living" which have been a guide in setting wage scales. However, living standards are largely individual and vary with the time and place. An amount that would mean comfort for one family would mean want for another; so variable are the purchasing skill, desires, intelligence, and judgment of the spenders. Furthermore, the size of families is a variable quantity, as is the number of wage earners in each. Some have claimed that a "living wage" is a misnomer; what the laboring man is entitled to is a "savings wage." That is, a wage sufficient to enable him to maintain himself and family in a reasonable degree of comfort, providing for his children a suitable education, retaining for himself a fair degree of the enjoyments of life, and still, through the practice of thrift, saving something of his wages for old age and the inevitable "rainy day."

Minimum Wages.—The Fair Labor Standards Act of 1938, popularly known as the Wage and Hour Law, has as its principal objective the elimination of "labor conditions detrimental to the maintenance of the minimum standard of living necessary for health, efficiency, and well-being of workers" and the elimination of "oppressive" child labor in the United States.

The wage sections of the Act apply particularly to industrial workers employed by manufacturers engaged in interstate trade. Agricultural laborers and several other classes are exempted. Minimum wages were established as follows: from October 24, 1938 to October 24, 1939, 25¢ an hour; from October 24, 1939 to October 24, 1945, 30¢ an hour; after October 24, 1945, 40¢ an hour. To reach as rapidly as is economically feasible the objective of a universal wage of at least 40¢ an hour, industrial committees study the conditions in each industry and make recommendations on the minimum to be enforced. Due regard is given to economic and competitive situations, so that the committees may lower the minimum in certain zones or for industries that cannot afford to pay the legal rate. As a consequence it has been the practice in many industries to establish lower rates in the southern states than in the northern. The Administrator may also set wages lower than the statutory minimum for learners, apprentices, and handicapped workers.

Since wages and hours of work are inextricably linked, maximum hours of work per week were established at 44 from October 24, 1938 to October 24, 1939, and at 42 from October 24, 1939 to October 24, 1940. After the last date the standard work week became 40 hours. All persons covered by the Act, except those engaged in interstate transportation and certain seasonal industries, who are employed a greater number of hours per week than the standard must be paid for the excess hours at a rate not less than one and one-half times their regular rate of pay.

Thus the state, in an effort to protect the welfare of society, has prescribed minimum wages for employees. These may tend to restrict some employment and to limit some small business enterprises, but the gain to labor more than compensates for the possible loss. Minimum wage legislation, however, is not a complete solution to the problem of low pay, for it does not guarantee that prices will remain stable.

Labor's Share of Income.—After industry pays for materials, repairs to equipment, and other operating costs, it pays about 77% of the balance for wages and salaries. What is left goes for dividends and into surplus accounts. Ford pays out nearly 94¢ of each dollar received for wages, materials, taxes, and other manufacturing costs. The remainder is largely used in building up and expanding his industry, including 52

branches in American cities. In the steel industry a dollar of income is distributed as follows:[2]

Labor payrolls	$0.37
Interest	.01
Surplus account	.02½
Taxes	.05½
Dividends	.05
Depreciation	.05
Material and all other costs	.44
Total	$1.00

In the period since 1900 labor's share of each dollar received by the steel industry has increased 50%, while the share taken by taxes has increased 800%.

Wages in the United States exceed those of any other country, both in amounts paid and in purchasing power. American steel workers can buy a market basket full of food for only 1½ hours' wages, while foreign workers in this industry must work from 3½ to 23 hours to buy the same amount.

Executive salaries, including bonuses received, average about 3% of the total payroll for several hundred large manufacturing companies. This figure provides a measure of the cost of management in providing leadership and coordinating the economic factors of land, labor and capital.

Stabilized Wages.—Seasonal and cyclical fluctuations of business are a hindrance to continuous employment and the paying of equal weekly wages throughout the year. However, wage earners are dependent in the main upon weekly earnings in order to live; hence stabilized earnings are an objective of progressive employers.

The George A. Hormel Company, meat packers of Austin, Minnesota, has an annual wage plan. This business is highly seasonal. From sales prospects the management estimates the probable production figures for the coming year. From motion and time study analyses the company knows just how much work this means for each department, and can arrive at the total labor costs. This amount the company agrees to pay in 52 equal installments. If business is better than estimated and work in some departments exceeds that planned, bonuses are paid. If output is less than anticipated, workers receive regular checks, but owe the company a certain amount of work to be performed later. If not made up within a given time, work debits are canceled. Bonuses are the usual result, however, because production estimates are purposely set low.

[2] "Half a Million Men," a booklet published by the American Iron and Steel Institute, New York.

Absent employees who are not receiving pay while on extended vacations or sick leave, are replaced by the management with men or money at the choice of the group concerned. The choice is usually money, which is credited to the group. By improving efficiency the workers also have cut labor costs to their own advantage. As a department finishes the day's run, employees go home. Conveyor operations formerly complained about, now operate too slowly to satisfy the workers. Labor turnover has been reduced to one-tenth of what it was, and wage earnings are the highest in the industry.

The Nunn-Bush Shoe Company, Milwaukee, Wisconsin, provides for 52 pay checks a year. The annual wage is not a definite amount, but an agreed per cent of the gross sales income, which is the labor cost. Wages thus rise and fall with prices. As costs are lowered by improvements in equipment or better methods the gains accrue to the workers. If competitors cut production costs and sell more cheaply, a share of these benefits may need to be diverted to management. The workers agree to action of this kind through their elected officials. Only 10 employees have been discharged in 23 years, and the workers upheld the action of the management in these cases. Wages paid are the highest in the industry, and labor turnover is very low.

The General Motors Corporation adopted a plan for its hourly paid workers which assured continuity of income. Workers with five years or more of service were guaranteed at least 60% of standard weekly earnings every week in the year. Workers with two to five years of service were guaranteed a minimum of 40% for a limited period—up to a credit of 72 hours of work at any one time. Pay for work performed elsewhere, or unemployment pay, was considered as a part of minimum earnings. When work was available later the employee repaid the company with his labor. One-half of his labor over the minimum amounts per week went for this purpose. If the employee failed to return to work after a layoff, the obligation was canceled. This plan operated well for several years, but was canceled when the company's regular activity was disrupted by the necessities of war.

Sears, Roebuck & Company has a standard income plan in its mail order plants. Workers receive 52 pay checks a year, and work the number of hours per week within reasonable limits as required by fluctuations in the volume of business. If the hours worked during the year exceed the standard set, after allowing for vacations and holidays, he receives a bonus; if less than standard, the shortage is written off by the company. Job tenure is not guaranteed. In case an employee is dropped he would receive a bonus for any excess hours worked, and any deficit would be written off.

Many other companies are operating or experimenting with similar plans.

The Sliding Scale.—During periods of rising commodity prices labor has found it difficult to maintain a uniform standard of living. This situation has often led to unrest and strife. Another cause for controversy occurs when the selling price of the company's product, and consequently the profit, increases or decreases because of favorable or unfavorable market conditions. Labor believes it should share in the company's prosperity, while management feels that under adverse conditions out of its control labor should be willing to take a cut in wages. An attempt to solve these controversies amicably, automatically, and equitably has been made by varying wage rates on some predetermined sliding scale based on either a cost of living index or the selling price of the industry's basic product.

The details of the plan and the method of determining the base upon which variations in the scale are to be made are set forth in a contract drawn up between the company and the employees' bargaining representative. When a cost of living or "market basket" index is used the statistics on prices may be derived either from local or national figures. When wages are based upon the selling price of the industry's finished product or basic raw material other considerations enter. The product selected should be one that has an established open market price, that is not monopolistically controlled, that moves in conformity with prices in general, and that is the controlling factor in the company's prosperity. Products that meet these requirements are coal, cement, pig iron, electrolytic copper, steel billets, and others of the same type.

The sliding scale is set beforehand and moves in conformity with changes in the index at stated intervals. Usually a minimum is set below which wages do not fall. The plan has not been adopted widely in the United States, but has many advocates abroad where monetary conditions have been unstable. It is an effort at paying stabilized real wages rather than mere monetary wages, and as such it deserves consideration when prices are moving rapidly.

Profit Sharing Plans for Employees.—Since 1794 employers in the United States have utilized profit sharing plans as a means of benefiting employees, and of enlisting loyalty and cooperation. They have not been uniformly successful; in fact many have failed. About all that can be said is that, for a particular company, profit sharing is a good thing if it works. Reasons for the failure of plans, include (1) opposition of organized labor, (2) employee dissatisfaction or indifference, (3) no profits, and (4) company dissatisfaction with results. When successful

they are "but one phase of a well integrated personnel program, and to secure the best results they must be adapted to the other industrial relations activities, including the wage payment system." [3]

Profit sharing plans provide for distribution of a share (1) of net profits, (2) of profits after payment of regular stock dividends, or (3) in some proportion to stock dividends. Most plans distribute profits on the basis of the employee's earnings. Other factors sometimes considered include rank and length of service. In the majority of cases managerial and wage earning employees share alike. Some companies grant the former group a higher percentage than the rank and file, while others may exclude the management group, or provide separately for each. Examples of successful plans are as follows:

The Eastman Kodak Company adopted a wage-dividend plan in 1912. It is apportioned according to each employee's earnings during the preceding five years, and amounts to ½ of 1% for each dollar of dividend declared over $3.50.

Procter & Gamble, of Cincinnati, started its plan in 1886. Employees earning less than $3,000 a year are eligible after 12 months' service. Earnings and length of participation in the plan determine shares as follows: 1 to 2 years, 5% of earnings; 3 to 4 years, 6%; 5 to 6 years, 7%; 7 to 9 years, 8%; 10 to 12 years, 10%; 13 to 14 years, 12%; after 15 years, 15%. For the first six years the employee devotes his share and dividends he receives to the purchase of stock. After that he collects cash dividends as indicated, but may continue to purchase stock if he desires. With this plan labor turnover has been reduced to less than ½ of 1%, and costs have been kept low. Employment has averaged 50 weeks a year.

Keystone Steel & Wire Company, Peoria, Illinois, distributes a share of net profits, as follows: 4% up to $1,000,000; 8% on the next $100,000; 12% on the next $100,000; 16% on the next $100,000; and 20% on all net profits over $1,300,000. With profits of $1,500,000, the profit sharers would get a dividend of 5.8%. For an employee earning $1,800 a year this would be $104.40 on total wages amounting to $2,000,000.

The Package Machinery Company, Springfield, Mass., issues a compensation warrant for each year of service. This includes paid-up life insurance of $100 and the earning power of two shares of common stock. The latter are nontransferable, and in event the employee leaves the company they are canceled. With this arrangement the employee benefits the same as from stock ownership, and the company's liability for capital stock is not increased.

[3] "Profit-Sharing and Other Supplementary Compensation Plans Covering Wage Earners," National Industrial Conference Board, Inc., New York.

The Idaho Maryland Mines Corporation shares profits so that employees benefit in proportion to the dividend rate on stock. The extent of individual participation increases with service up to two years, starting at six months. The plan as it works out pays qualified employees more than most stockholders receive.

Sears, Roebuck & Company has had a plan in effect for 22 years which calls for the employees to contribute 5% of their salaries up to $5,000. The company contributes 5% to 7½% of its profits per year. This fund is invested in Sears stock. After ten years the employees may withdraw their savings, plus interest, in cash or Sears stock. The returns to employees have been about $4 for every $1 contributed.

In sharing profits employees must be educated to the fact that profits are not a part of regular wages.

In the Ilg Electric Ventilating Company, of Chicago, the yearly salary of each employee is considered as his investment. The per cent paid on these "investments" is determined at the end of the company's fiscal year by the directors, and ranges from 2% to 30%. To this is added a length of service bonus, starting with 5% of the above bonus for two years, and reaching a maximum of 50% for eleven years. The total has averaged about 4% of wages over a long period. For example, an employee whose yearly salary was $1,600 would receive a profit sharing bonus of $320 in a year when 20% was declared. If he had served for six years his extra bonus would be 25% additional, or $80, making a total of $400 for his share of the profits.

Bonus Awards to Supplement Wage Payments.—Bonus systems are designed to share the benefits which accrue from superior effort on the part of employees. In some forms they are similar to premium plans and in others approximate profit sharing. Bonus awards may be for attainment in any one of many directions, such as quantity of output, quality, length of service, decreased costs, saving of materials, reduced labor turnover, or for teaching new workers.

Bonus plans can be extended to managerial effort, clerical and accounting work, and day work; that is to say, to forms of effort not readily measurable by time study and to which individual wage incentive plans are not readily applicable. Examples of industries where these may comprise the major portion of wages are public utilities, transportation, and jobbing and repair shops.

The payment of the bonus is generally made in a lump sum either every six months or once a year. More frequent payments may be made, but it is common to wait until the end of the year, around Christmas time, when results of operations can be determined accurately. Fairly large

payments, given as an arbitrary amount or as a percentage based on individual earnings, have been made by some companies. Indifferent workers and slackers find an uncongenial environment and are weeded out, for if the plan is a success employee cooperation is secured, labor unrest minimized and individual initiative encouraged. Success or failure is dependent upon winning the workers to the plan.

Labor leaders are usually opposed to bonus award plans, on the ground that the daily wage is lower because of them, and that they subject employees to uncertainties beyond their control. With unintelligent workers difficulty is experienced in getting them to understand the idea and interest is usually lacking. Semi-annual or annual awards of uncertain amounts may prove too vague and remote to stimulate initiative in overcoming obstacles day by day. When received, such awards have little connection with individual merit. As in profit sharing, the workers are dependent upon management for the correctness of calculations, and for decisions as to amount awarded; and likewise, the efficiency of management influences greatly the accumulated earnings.

Rating the Job.—The task of classifying jobs and determining equitable base rates for them in harmony with the ideas of workers and management as to their relative importance is fundamental to all wage plans.[4] Job rating plans have been developed for industries, but individual applications usually vary somewhat. The needs of a particular plant should be reflected in the plan used. Factors which may be taken into consideration in arriving at the worth of a job are indicated by the following examples from practice.

The United States Gypsum Company uses the job rating sheet shown in Figure 127. Twenty-four factors are used, and each is rated on a scale from 0 to 5.

The Goodrich Rubber Company plan includes ten factors, of varying importance, as follows:

Factors Considered	Maximum Points
1. Supervision exercised by operator	5
2. Judgment required by operator as to quality of product	10
3. Responsibility for material and quality	20
4. Responsibility for equipment	5
5. Manual dexterity	15
6. Working conditions (dust, heat, etc.)	10
7. Hazards	5
8. Physical requirements	5
9. Educational requirements	5
10. Learning period	20

[4] One large middle-western company found that it had 400 day-work jobs and 600 piece-work jobs in its shops, the former of which were divided into 18 groups. Rates were set by combined committees of men and management.

JOB RATING

NAME OF JOB .... DEPARTMENT ....

DESCRIPTION ....

DATE .... RATED BY ....

FACTORS	0	1	2	3	4	5	SCORE
A. JOB REQUIREMENTS — WHAT MUST BE DONE							
1. Complexity of Work (Manual)	*None*	*Simple*	*Semi-Complex*	*Complex*	*Very Complex*	*Extremely Complex*	
2. Complexity of Work (Mental)	"	"	"	"	"	"	
3. Volume of Work	"	*Extremely Small*	*Noticeably Small*	*Moderate*	*Large*	*Extremely Large*	
4. Care & Exactness	"	*Unimportant*	*Semi-Important*	*Important*	*Noticeably Important*	*Extremely Important*	
5. Confidential Work	"	"	"	"	"	"	
6. Hazardous Work	"	"	"	"	"	"	
7. Planning of Work	"	"	"	"	"	"	
8. Supervision Exercised (Quantity)	"	*3*	*4-10*	*11-20*	*21-50*	*51 Up*	
9. Supervision Exercised (Quality)	"	*Simple*	*Semi-Complex*	*Complex*	*Very Complex*	*Extremely Complex*	
10. Public Contact	"	*Unimportant*	*Semi-Important*	*Important*	*Noticeably Important*	*Extremely Important*	
B. WHAT THE JOB REQUIRES THE WORKER TO BE							
1. Age	"	*17 or Below*	*18-21*	*22-26*	*27-32*	*33 Up*	
2. Physique	"	*Unimportant*	*Semi-Important*	*Important*	*Noticeably Important*	*Extremely Important*	
3. Dress	"	"	"	"	"	"	
4. Mental Skill	"	"	"	"	"	"	
5. Character	"	"	"	"	"	"	
6. Loyalty	"	"	"	"	"	"	
7. Aggressiveness Initiative	"	"	"	"	"	"	
8. Creativeness Imagination	"	"	"	"	"	"	
9. Analytical Ability	"	"	"	"	"	"	
10. Enthusiasm	"	"	"	"	"	"	
11. Personality	"	"	"	"	"	"	
C. WHAT MUST BE KNOWN							
1. Education	"	*8 Yr.*	*10 Yr.*	*12 Yr.*	*4 Yr. College*	*Profession Technical*	
2. Knowledge of Job	"	*Unimportant*	*Semi-Important*	*Important*	*Noticeably Important*	*Extremely Important*	
3. General Experience	"	"	"	"	"	"	
						Total —	

Figure 127. Job Evaluation Form Used by United States Gypsum Company

A motion and time study engineer analyzes each operation and reports as follows:

1. *Job Description.* Write a brief but accurate general description of the kind of work embraced in this position.

2. *Supervision Received.* State name of position to which this one directly reports. Describe nature of supervision received, as immediate, general, continually checked, follows detailed directions, follows general instructions but executes them upon own responsibility.

3. *Supervision Exercised.* State briefly what occupations and how many are in any way directed or supervised by this one, and describe nature of supervision exercised. State what initiative and judgment are required.

4. *Responsibility for Materials and Equipment.* State briefly the responsibility of this position in regard to the value of the materials and equipment handled or used.

5. *Manual Dexterity Required.* Give a description of any skill above ordinary required in this position.

6. *Physical Requirements.* State briefly what physical requirements are necessary for an operator in this position.

7. *Hazards or Unpleasant Working Conditions.* Explain briefly the hazards and unpleasant conditions encountered on this operation.

8. *Educational Requirements.* State briefly the necessary educational requirements.

9. *Experience and Previous Training Required.* Explain briefly what experience and previous training are essential, also approximate length of learning period.

All data are discussed by a committee. The individual members of the committee then rate the importance of each factor independently, being guided by standards of value previously established for each factor, by experience in rating other jobs, and by judgment. An average of final conclusions is then made, and expressed as a numerical figure. The maximum points for any job would be 100. The jobs are then classified as being in zone A, B, C, etc., according to the points allowed. A base wage rate applies to each zone.

Rating the Employee.—Employee rating plans are used to determine distinctions between individuals just as job rating plans are used to evaluate different classes of work. In this manner more equitable wage payments can be established. The following plan is in operation in a large manufacturing company in Chicago. The proper classification of the individual is arrived at by evaluating him in three respects:

1. *Personal assets of workman*—such as experience, knowledge of work, dependability, loyalty and shop attitude, judgment, initiative, ability, and all other such qualities which go toward making up the most desirable type of workman.

2. *Production*—performance or the accomplishment of the workman.

3. *Quality of production*—quality of work performed, taking into consideration scrap and spoiled work.

It is quite obvious that a workman with the very best personal assets capable of maximum production of best quality is the ideal or 100% workman. If these three factors are of equal value then 33⅓% would represent the value of each, but it is thought that "Production" and "Quality" should be considered the more important features and the following score has been decided upon.

Personal Assets	30%
Productivity	35%
Quality	35%

The score then of 100% represents the ideal workman and the question is how to measure the individual worth of various employees. In classifying a group of workmen it will develop that owing to the different individual characteristics of men that some may score excellent, good, fair or poor under each of the three factors outlined. Using the four foregoing qualifications and applying the letters A, B, C and D for designation purposes the following formula develops:

	Personal Assets	Productivity	Quality
Excellent	A	A	A
Good	B	B	B
Fair	C	C	C
Poor	D	D	D

An example of rating men in the Tool Maker group is as follows:

	Personal Assets	Productivity	Quality
John Harris	A	B	A
Paul Smith	B	C	B
W. Morrison	B	C	C
Sam Gray	C	C	D

The next step is to determine the score for each worker. The ideal or 100% worker's score as illustrated in Personal Assets, 30%; Productivity, 35%; Quality, 35%.

Let a score of A, 90 to 100%, represent excellent.
B, 80 to 90%, represent good.
C, 70 to 80%, represent fair.
D, 60 to 70%, represent poor.

We then have

	Personal Assets	Productivity	Quality
Excellent	A - 30%	A - 35%	A - 35%
Good	B - 25%	B - 30%	B - 30%
Fair	C - 20%	C - 25%	C - 25%
Poor	D - 15%	D - 20%	D - 20%

and our Tool Makers will have total scores as follows:

	Personal Assets	Productivity	Quality	Total
John Harris	30%	30%	35%	95%
Paul Smith	25%	25%	30%	80%
W. Morrison	25%	25%	25%	75%
Sam Gray	20%	25%	20%	65%

The Occupational Rating plan suggests a spread of $1.00 to $1.25 per hour for the Tool Maker occupation. This spread is split as follows:

6¢ for a C grade workman, or $1.00 to $1.06 per hour.
8¢ for a B grade workman, or $1.07 to $1.14 per hour.
11¢ for an A grade workman, or $1.15 to $1.25 per hour.

Applying these values to the above scores we have:

John Harris, score 95%—an A grade workman—$1.15 to $1.25 per hour.
Paul Smith, score 80%—a B grade workman—$1.07 to $1.14 per hour.
W. Morrison, score 75%—a C grade workman—$1.00 to $1.06 per hour.
Sam Gray,[5] score 65%—a D grade workman—poor.

It will be noticed that the greatest spread of money falls within the A classification and it is felt that this amount will be large enough to take care of the highest grade workman on the job. The administration of the spread in rates is subject to the recommendation of the foremen to the superintendent or some other party designated by him. The local plant Occupational Rating Committee through its chairman or secretary will function as a means of checking and investigating all day work rate changes, passing its recommendations along to the superintendent. The committee as a whole will meet only when occasion arises subject to the call of the chairman or secretary. In some cases the occupation at one plant may not necessitate the highest grade workman, and consequently the larger spread in rates would not be warranted. The plant committee will meet periodically to check all rates, paying particular attention to the administration of the A, B, and C rates.

Wage Plans for Beginners.—Whatever plan of wage payment is adopted for general use some special arrangement will need to be made for beginners. The policy will necessarily vary somewhat depending upon the wage plan in effect, the length of the training period, the character of the work, the type of employee, and his probable future in the plant.

[5] In the case of Sam Gray it is hardly possible that he would be retained and recognized as a Tool Maker.

A flat day rate increased at intervals is not unusual. A better plan may be a combination of day wages with piece rates, the former decreasing as the training period nears its close until the worker is dependent on piece rates entirely. However, proficiency at a new task is not gained at a uniform rate, as might be supposed. Figure 128 shows a typical curve of progress for new workers. It will be seen that there is an intermediate period when little advancement is made, preceded and followed by periods of comparatively rapid progress.

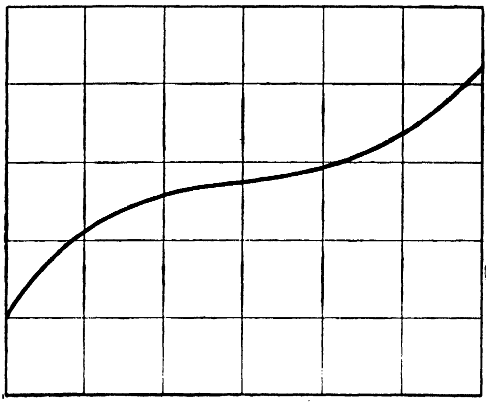


Figure 128. Typical Progress Curve for New Workers

Figure 129 is a graphical record of progress made by a young woman learning a sewing operation. Workers, particularly women, unaware of this unevenness in the rate of progress, are apt to become discouraged at their inability to earn wages based on expected uniform production increases. To avoid the unnecessary and costly labor turnover which may ensue, wage plans should fit the conditions prevailing and assure the beginner of a fairly uniform and constant wage increase during training.

Workers are especially sensitive to impressions during their training period, forming lasting judgments of management, and every care should be exercised to make their remuneration fair and just. Those exceeding expected production rates should be rewarded according to output in order that they will have every incentive for aggressive mental and physical effort.

Supervisor Bonuses.—Foremen are frequently paid bonuses in proportion to the incentive earnings of those they supervise. This practice measures the results attained. As a means of improving basic conditions which will permit savings to be made, output increased, and costs controlled, a more comprehensive plan may be justified. The factors to be

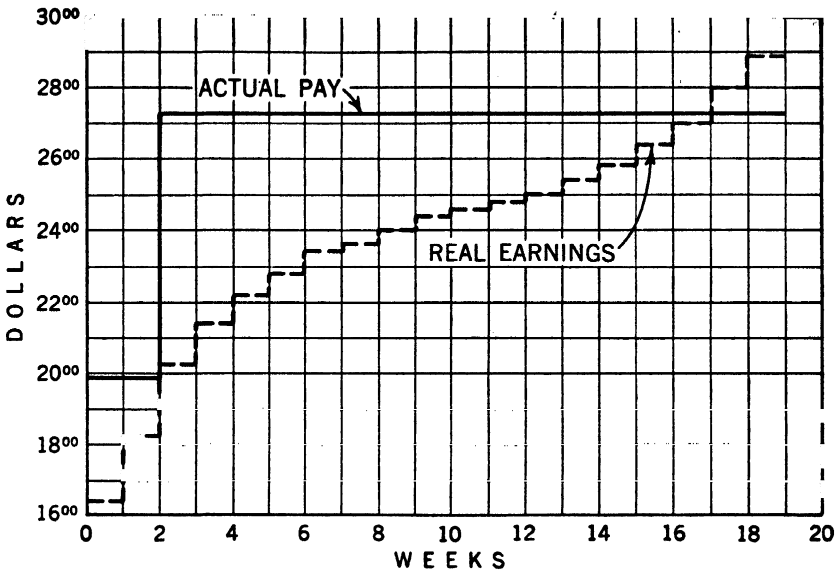


Figure 129. Chart Showing Rate of Progress, Pay and Actual Earnings of New Worker Learning a Task

included will be those over which the foreman has control. The following is an example of a supervisor's bonus plan in a company making household electrical equipment.[6]

Factors considered and their relative importance are:

1. Departmental Efficiency—Critical evaluation of departmental efficiency as reflected in costs, workers' earnings, etc.—50%.
2. Budgetary Control—Based on condition of departmental operating expense budgets—15%.
3. Quality Control—Based on condition of scrap and rejected materials as compared to the amount of good materials produced—15%.
4. Control of Excesses:

   (a) Excess Daywork—Control of excess daywork allowances made to incentive plan groups over and above regular allowances—5%.

[6] "John Q. Supervisor Can Savvy This Bonus Plan," by J. E. Osterman, *Factory Management and Maintenance*, Vol. 96, No. 6, p. 52.

(b) Excess Overtime—Control of excess overtime due to poor planning and mismanagement on the part of the supervisor—5%.

(c) Excess Materials—Control of productive material requirements in excess of specified quantities—5%.

5. Base Rate Control—Control of base rates, operating within or under standard base rates established for the various tasks of the department—5%.

SUPERVISORY BONUS ANALYSIS

DEPARTMENT "A" JOHN DOE, SUPERVISOR APRIL

Elements	*Grade*	*Extension*	*Penalties*	*Bonus*
a. Department Efficiency	.50			
b. Budgetary Control	.15			
c. Quality Control	.15			
d. Excess Daywork	.05			
e. Excess Overtime	.05			
f. Excess Materials	.05			
g. Base Rate Control	.05			
h. Supervisor's Salary		$200.00		
i. Department Efficiency		125.00%		
Bonus = (i — 100%)ha = 0.25 x $200 x 0.50				$25.00
j. Budget Allowance		$600.00		
k. Budget Expended		$500.00		
Bonus = (j — k)b = $100 x 0.15				$15.00
l. Scrap Allowance		$500.00		
m. Actual Scrap		$550.00		
Bonus = (l — m)c = —$50 x 0.15			$7.50	
n. Allowed Daywork		$50.00		
o. Actual Daywork		$25.00		
Bonus = (n — o)d = $25 x 0.05				$1.25
p. Allowed Overtime		$50.00		
q. Actual Overtime		$75.00		
Bonus = (p — q)e = — $25 x 0.05			$1.25	
r. Excess Materials Allowed		none		
s. Actual Excess Materials		$10.00		
Bonus = (r — s)f = — $10 x 0.05			.50	
t. Labor at Standard Base Rates		$2,500.00		
u. Actual Labor		$2,450.00		
Bonus = (t — u)g = $50 x 0.05				$2.50
Total			$9.25	$43.75
Net Bonus Paid				$34.50
Note: All negative results become penalties				

Figure 130. Example of Computation of Supervisor Bonus

Other elements of supervision, such as deliveries, consistency, good housekeeping, should be considered in the bonus plan if deemed of sufficient importance. The way in which the bonus earned by a supervisor is computed is illustrated in Figure 130.

Incentives for Inspection.—The work of inspectors is frequently upon a time basis, but many inspection tasks are of a nature which permits the application of incentives. Inspection tasks which are repetitive and consequently similar to operation jobs may be handled in the same way. Quality standards are set. Then the best way of doing the job is determined, and inspectors are trained. Arrangements should also provide for a routine check or reinspection on an interval or percentage basis. Any good incentive wage plan will apply.

A rating plan for inspectors used by one large company making many small piece parts is as follows:

$$\frac{D-K}{D-K+B} \times 100 = \text{Rating}$$

Where D = Number of defects reported by inspector.
K = Number of good parts rejected by inspector.
B = Number of defects missed by inspector.

A check of each individual's work at intervals provides a basis for judging the effectiveness of inspection.

Another plan for women inspectors used in a job shop divides work into classes, ranging from that done by beginners to extreme precision work trusted only to the most experienced.[7] Points are assigned to each class in accordance with the relative judgment required. See Table 12. The type of worker is also important. Factors influencing the worker situation are indicated and graded in Table 13. Production standards are expressed in units (man-minutes of work). The number of units per 100 minutes is used for comparative ratings, and as a basis for bonus earnings.

TABLE 12. CLASS OF WORK

Class of Work	Points
1	5
2	10
3	15
4	20
5	25
6	30

TABLE 13. THE WORKER

	Points			
	Poor	Fair	Good	Perfect
Attitude	1	2	3	4
Supervision	1	2	3	4
Experience	1	3	5	7
Versatility	1	2	3	4
Quality of work...	2	5	8	11

To obtain the rating for individuals which is done every three months, each inspector's job is analyzed, and her points in Tables 12 and 13 are totaled. This will place her in one of the groups from A to F as shown

[7] "Job Shop Inspection on Bonus," by William R. Mullee, *Factory Management and Maintenance*, Vol. 95, No. 5, p. 58.

in Table 14. Knowing her production average her premium earnings are indicated in the table. No extra premium is paid for production in excess of 120 units in 100 minutes, because of possible adverse effect of speed on the work.

TABLE 14. PREMIUM RATES PER 100 MINUTES

	Inspection Class					
Production Rate	F To 23	E 24–31	D 32–39	C 40–47	B 48–55	A 56 Up
To 95	$ .00	$ .02	$ .04	$ .06	$ .08	$ .10
96–101	.02	.04	.06	.08	.10	.12
102–107	.04	.06	.08	.10	.12	.14
108–113	.06	.08	.10	.12	.14	.16
114–119	.08	.10	.12	.14	.16	.18
120 Up	.10	.12	.14	.16	.18	.20

As a basis for the plan job standardization and motion study are completed, and instruction cards provided which define each task and tell the inspector what to do.

Incentives for Maintenance.—Larger companies need to establish incentives for maintenance work in order to control costs. Smaller companies may disagree as to the effectiveness and value of such plans. The nature and diversity of the work and the varying location of many similar jobs makes the work complex.

Some large companies have kept track of maintenance work of each kind until sufficient data were obtained to permit task times to be set at least approximately on a basis of experience and judgment. The use of some form of premium or bonus plan then provides an incentive to workers. Large sums have been saved in this way.

Motion and time study provides an effective approach to maintenance incentives. Each kind of work studied separately may be analyzed for standard elements and time standards prepared. Incentive pay may then be earned in the same way as for shop jobs. Care must be exercised that the plan in operation does not foster a lack of thoroughness, or inattention to possible causes of future interruptions to production.

CHAPTER 26

WAGES—COMPARISON OF WAGE PLANS

Selection of a Wage Plan.—The objectives of any wage plan should be low unit costs, high wages and increased production. To be most effective with workers a plan must combine ease of understanding, fairness, increased earnings as a reward for individual efforts, and must give protection from the practice of rate cutting. Labor has undoubtedly been correct in its criticism that wage plans may be made to reflect the ideas and ideals of management and are not infallible on their own account. In regard to wages the worker is not ignorant, and any belief that he can be fooled is a fallacy. Management requires that a wage plan be simple and economical to administer, provide a real incentive, facilitate accounting and cost control, decrease costs, and promote harmony and good will.

Of primary importance with any system are: (1) the base rate per hour, (2) time allowance for the job, and (3) the amount of incentive offered.

With standardized conditions and properly set rates individual earnings will not vary greatly. The success or failure of any system of wage payment is largely dependent upon its proper introduction and administration. For this reason and because standard times used may vary with different plans and in different plants, the various plans are not strictly comparable. Production data are given with each plan, however, in order that the general effects may be noted and comparisons made where warranted.

Types of Wage Payments.—Plans for the payment of individual workmen fall into three general classes: (1) those based upon the time worked—time wages; (2) those based directly upon production—piece rates; and (3) those which are a combination of time and production, generally based upon the amount of time saved from a set standard—premium or bonus plans. Many systems have been developed under each class, but the greatest attention has been given to the so-called premium plans, for they are considered the most scientific. They offer an incentive to the worker not only to increase his production but to improve his worth to the company in other respects. By doing this he will raise his hourly pay, which is the base upon which the premium is figured.

Besides wages based upon individual performance, premiums also may be determined by the production of a group. These group plans aid in developing a spirit of cooperation while at the same time they pay an individual wage. A few of the many wage plans that have been developed will be presented in the following pages and a comparison made between them. Each offers some particular feature which has been thought desirable to meet certain working conditions or call forth greater effort on the part of the workers.

Trends in Wage Payment Plans.—The use of incentive wage plans increased steadily during several decades. After 1933, however, there was a noticeable trend toward the payment of wages on a time basis. This was due to two principal causes. First, the increased strength of labor unions and collective bargaining has resulted in several contracts that specify rates at so much per hour. Most labor unions prefer time wages even when they are not openly antagonistic to incentive plans. Such a system promotes collective bargaining by union representatives, and places the responsibility for increased pay upon joint action rather than the effort of individual workers. Hence the incentive to unionization is strengthened. Labor organizers have also convinced many workers that incentive plans, particularly piece rates, were connected with the "speed up" system and injurious to the workers. It is true that workers generally work harder when they are paid to do so, but there is little indication that this results in speeding up to a point where harm results.

The second reason for the change to time wages has come from the increasing mechanization of industry, especially in mass production or assembly line operations. In mass production the output of an individual is governed by the speed with which materials are brought to him. He cannot work faster than the group, and if he is not able to maintain this speed he is removed to another job. Ford, of course, always preferred time wages, and most of the other automobile plants had already changed many of their workers to this method of payment before the union demanded its universal application. High time wages and guaranteed employment reduce labor turnover and thereby greatly increase group efficiency. Inexperienced or indifferent workers slow up the entire group.

Union demands often control the type of wage plan used and the rate paid. When management is free to make an open choice the effect upon production is considered. Observation and study of various types of payment disclose that when wage incentives are lacking production usually decreases.

Payment of Time Wages.—The payment of time wages where all workers in the same class receive the same wages, and individual produc-

tion records are not kept is considered unsatisfactory. When carefully thought out production methods are in effect, and task times are accurately set, time wages may prove successful.

In the smaller shops the personality of the owner makes itself felt in a more effective supervision, better discipline, and higher standards of production. Each worker is under the appraising eye of a competent judge, and is more likely to receive the consideration he merits.

In large factories, particularly in the past, the situation has been quite different. Foremen are often not craftsmen, and administration is necessarily more impersonal and dependent upon system. The trend, too, has been toward the perfection of machinery and equipment, while the human element until very recently has been neglected. For a considerable period, workers were seemingly regarded as merely adjuncts to machines, and individual identities were overlooked. Lacking individual production records and proof of superior merit, employers were reluctant to discriminate by wage differences between individuals doing the same kind of work. To do so meant trouble with the group.

> This method of buying labor is similar to buying materials sold under the same name at the same price, without regard to quality; but it is much more wasteful, as the difference in the quality of materials is seldom as great as the range of efficiency in workmen.[1]

With working conditions standardized, maintenance provided for, a plan of production control inaugurated, the best method and standard time of doing each task a matter of record, and the workers trained in these procedures, the time method of payment takes on a new aspect. Guesswork is eliminated. Each workman knows exactly what is expected of him in return for a day's pay, and records are kept of individual outputs. Thus each workman may at any time ascertain his standing, and the management in turn has a definite basis for individual wage increases and promotions. The individuality of the worker is restored. Frederick W. Taylor discovered that output could be increased two or three times under these conditions, when the worker was offered a proper wage incentive for extra effort.

Examples of Successful Use of Time Wage Plan.—The Caterpillar Tractor Co. uses the time wage plan with success. Individual records are kept of each man's daily output, and with improved performance consideration is given to wage increases. In general three wage levels for each job are in effect. Promotions and wage increases following meritorious work stimulate other workmen and raise shop morale.

[1] Work, Wages and Profits, by H. L. Gantt, p. 65.

A large machine manufacturing company utilizes both the time wage and piece-rate plans in effecting payment of wages to over 40,000 men in a score of different plants. By the use of job rating the worth of individual jobs is determined and wages are based accordingly. The workers are also evaluated according to their merits as was suggested in Chapter 25.

The use of such a classification will lessen the danger of an employee of the more aggressive type who is continually after more money faring better than his bench or machine mate who is less aggressive and diffident in "tackling" the boss for increased remuneration. At the same time, the latter employee may easily be worth much more to the company than his fellow employee who has his pay envelope continually on his mind.

One will readily see that the foregoing classification and rating scheme is nothing more than something which the foreman already has or should have in use, except that certain basic principles are established by which the work may be more impartially administered.

Foremen or other parties using a basic set of principles involving educational features for the scientific administration of day work rates, will be instrumental in helping to bring about a more equitable remuneration for services rendered, reduce the number of requests for wage increases and be the means of creating an incentive for the lower classified workmen.

The Standard Day Wage Plan.—This plan is simply a modification of the piece-work plan. Standards of performance are agreed upon and employees accept the responsibility for producing these amounts each day in return for a given wage. The management undertakes to provide continuous work. Given the opportunity and failing to attain the standard, the worker is virtually upon a piece-rate basis, being paid for the amount which he has completed. Should the management fail to supply materials upon which to work it is penalized by payment of wages on a time basis for the inactive time of the worker. This system has been successfully used in the clothing trades. With an agreement of a minimum number of hours of employment per week, it puts squarely up to the management the responsibility for efficient administration, but does insure a fixed cost of production if this is provided, as in piece work. To the employees, continuity of work, which is of even more importance than the wage scale, is guaranteed in return for performing a day's work the quantity of which has been determined jointly. Both parties are stimulated to put forth their best efforts, resulting in increased production, which lowers the total unit cost by decreasing overhead.

The Payment of Piece-Rate Wages.—The introduction of piece rates marked the beginning of payment for accomplishment rather than

for time. It was an attempt to individualize workmen, foster initiative, and substitute the appeal of self-interest for the fear and "drive" of the foreman. To divide the daily wage by the average daily production to ascertain the cost per unit was a simple matter. Recognizing that the best workers could earn considerably more than day wages under this arrangement, the piece price was sometimes set slightly lower than this average cost in order to divide the increased earnings, but usually the employer was content to profit by the increased production and consequent reduction in overhead expenses. A direct saving in labor costs was effected in the case of sub-standard workers.

The individual piece-rate system is particularly applicable to repetitive work and tasks which are readily measurable; operations performed by individuals and which yield a product readily inspected, counted, and credited after each operation. It appeals to energetic, skilled workers who find in it the opportunity to profit by their ability to produce more and exercise their ingenuity in improving methods.

Group piece-work is used largely in assembly operations, for tasks requiring the cooperation of two or more for their completion, or involving many short, simple operations. In such work individual piece rates would prove impracticable because of the amount of clerical work, inspecting, counting, and crediting involved. With group piece rates responsibility for poor work rests with the group and intermediate inspection may be dispensed with. Supervisors, truckers, and other indirect labor may be included with the group, assuring the collective efforts of all contributing to output. The plan is especially effective with small groups numbering up to 15 or 20 who cooperate in completing a common task, as an assembly unit. It is sometimes used with groups numbering a hundred or more, and evidently to advantage.

Piece Rates Set on Past Records.—In plants where programs of motion and time study have not been undertaken piece-work is less effective. Good workmen know the possibilities for improvements in working arrangements and if offered sufficient incentive will effect improvements. In these instances the worker gets the saving made and is stimulated to aggressive mental and physical effort. Slow workers and those on tasks not readily measurable are not so well disposed to piece-work. Also there is the feeling on the part of the workers that on tasks where accomplishment is not established on a basis of past experience, as in the case of new or unfamiliar work, rates will be set which favor the management. Many rates are often mere guesses; some are "easy" and some "hard."

Abnormal piece rates may have a demoralizing effect on employees. Rates which are too low cause dissatisfaction, while those which allow

unusually high earnings may cause the workers to slow up and thus reduce outputs. Workers receiving abnormally high earnings would be fearful of cuts in rates. Once the employees get the idea that they are to be permitted to earn certain amounts and no more, the incentive to increase production is ended. From that time on, it is likely to be a game between the two opposing forces, one to get the maximum earnings from a minimum amount of work, and the other to get maximum production for only a little more than the usual day rate for the class of work in question. This situation keeps production averages somewhat low, and overhead high as compared with other plans.

Workers on piece rates are likely to be hindered by poor management in making high wages. Failure to deliver materials promptly, faulty production control, intermittent orders, improper tools and equipment, and lack of maintenance are factors to be reckoned with. The best workers gravitate to those plants where conditions in these respects are best. Under the day work plan some employees are carried during slack periods, and for others the work may be prolonged somewhat, but the piece-worker cannot stretch his job to his own profit.

Changes, improvements and alternating periods of prosperity and depression call for rate adjustments. Changing designs and styles make such adjustments imperative. The workers oppose them, often bitterly, when the old rate is "easy" and the new one "hard," feeling that in many instances the adjustment is but an excuse to reduce earnings. Without question high piece rates are a constant temptation to the management and an incentive to make changes which will lower cost. On the other hand, in industries where the unions have a strong grip the rigidity of rates may prove a real hazard to the industry. Thus there is continual ground for bickering and cause for ill-feeling. The high production theoretically possible is not often attained and the lower production rates and high overhead common to unstandardized day work environment are perpetuated. Inequalities in rates are a source of irritation to workers, and the competitive spirit, each man for himself, may not be conducive to teamwork and good morale. Increased attention must be given to inspection to guard against slipshod and careless work. The custom of guaranteeing rates for a year stabilizes the situation somewhat. The application of the piece-rate system to unstandardized plants is at best only a partial success.

Piece Rates Set by Time Study.—Applied to standardized plants with progressive management piece rates may prove quite acceptable to all parties. This implies the same initial work in plant improvement and equipment standardization, establishment of task times and keeping of

individual records as suggested for the successful use of the time payment plan.

Piece-rate operators require more than an immediate wage incentive. There must be steady work and opportunity for advancement to better paying jobs if the best men are to be secured. Order then emerges from chaos, harmony replaces strife, and teamwork takes the place of divided interests.

While direct labor costs are fixed, the plan leaves overhead costs as an uncertain quantity, which affects accounting, estimating and budgeting. Workmen like the plan because of its simplicity and the fact that

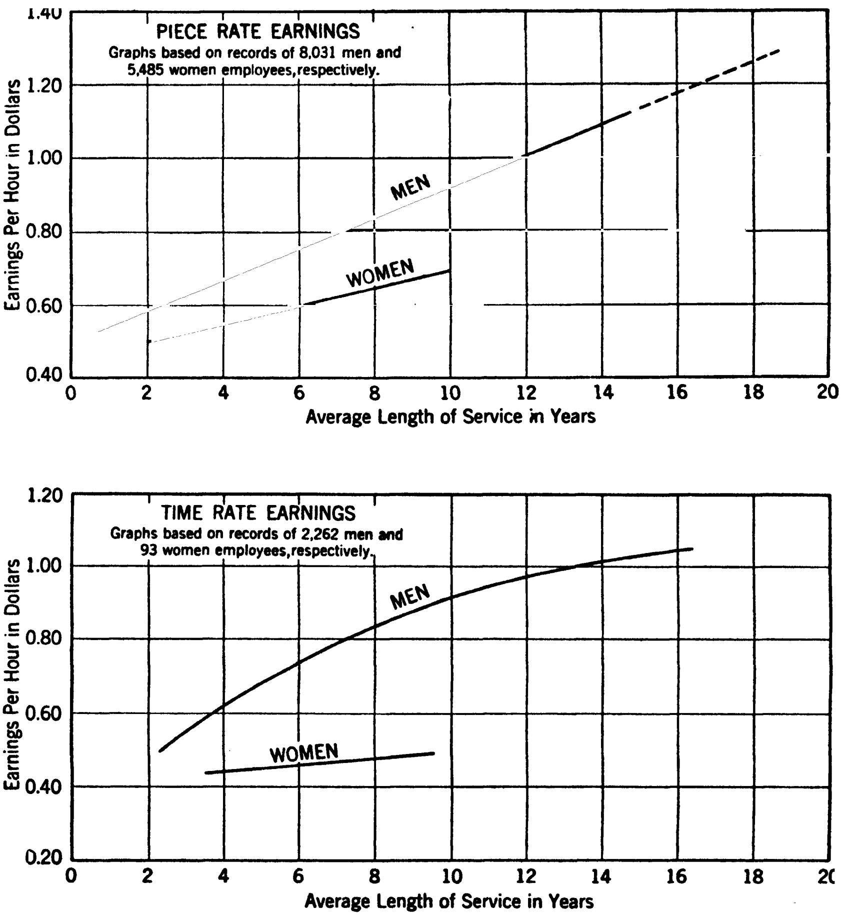


Figure 131. Charts Showing Progress in Wage Earnings With Experience and Length of Service

pay is proportional to output. However, recognition should be given to length of service and personal qualities of the worker. Under standardized conditions the success of the system is dependent upon good shop management and wisdom in its administration. The relation between earnings and the experience and length of service of shop workers is shown by the charts in Figure 131.

Premium Plans of Wage Payment.—These plans differ from the piece-rate system in that task standards are usually expressed in time units rather than money. Workmen may be hired on an individual basis and paid hourly rates commensurate with the estimated value of their services, considering personal qualifications, length of service, etc. With variations in the cost of living, wages can be adjusted without disturbing the standard time. Day wages may or may not be guaranteed. Standard times are usually such that the average worker will earn a certain predetermined premium, as 25% above the basic day rate with a normal day's output.

Considering a particular task, assuming that the rate per hour is $.60; standard time 8 hours; actual time 6 hours; 100% premium, the plan would operate as follows:

$$\text{Wages} = (6 \times .60) + (2 \times .60) = \$4.80$$

Workers receive the benefit of all time saved. Excepting for substandard workers who may be shifted to other work, labor costs remain constant, the cost per piece remaining the same regardless of the premium earned by the worker. It is apparent that the plan may be modified to pay the workers any per cent of the savings desired. The system has all the advantages of the straight piece-work plan and in addition allows workers to be rated in the same manner as in a time wage plan.

The premium plan of wage payment is readily applied to the work in tool rooms, storerooms, receiving and shipping departments. Outputs are measured in terms of value, bulk, weight or number of units or orders handled. Added compensation may then be allowed for extra outputs. Such a plan provides incentive in what are usually considered day work occupations. As the volume of work increases or men leave, it frequently happens that more work per man is willingly undertaken, and additions or replacements are unnecessary. Higher wages are thus paid, labor turnover reduced, and plant morale benefited.

The Halsey Wage Plan.—The first of the various premium wage systems was devised by F. A. Halsey, a factory superintendent. The plan guarantees day wages, uses previous average production as a standard of performance, and offers the worker from one-fourth to one-half of

the value of time saved. The premium is calculated on each job separately, so that failure on one job does not sacrifice the premium earned on another. The plan differs from day wages in that workmen get extra pay for increased production, and from piece-work in that the rate of pay per piece decreases as the output increases. Considerable savings are ordinarily possible, but as they are divided between the worker and management there is not the same temptation to cut rates as in straight piece-work operations. The time allowances are liberal, rather than the premium. Expressed in a formula the plan is as follows:

FORMULA FOR EARNINGS

1. Up to task:

   Earnings = Time wages = $H_a R_h$

2. At and above task:

$$\text{Earnings} = \frac{\text{Time}}{\text{wages}} + \frac{\text{Hours}}{\text{saved}} \times \text{a fraction * of the rate per hour}$$

$$= H_a\, R_h + \frac{(H_s - H_a)}{4}\, R_h$$

$$= \frac{R_h\,(3H_a + H_s)}{4}$$

Where H_a = Actual hours taken; R_h = Rate per hour; H_s = Standard time in hours

For a particular task, assuming that the rate per hour is \$.60, standard time 8 hours, actual time taken 6 hours, bonus 33⅓%, the plan would operate as follows:

$$\text{Wages} = (6 \times .60) + (2 \times 1/3 \times .60) = \$4.00$$

The advantages of the plan are several. It is easy to introduce, because established methods of work are not changed, and averages of past performances are used as standard times. It serves to "coax" the workers to accomplish more, without any penalty for not doing so, and leaves the acceptance of bonuses as optional. The psychology of the plan is good in that the emphasis is placed on time saved rather than increased production. The guaranty of day wages appeals to beginners and slow workers.

There are some important disadvantages. Job standards set in the manner suggested will prove inconsistent, with resulting "easy" and "hard" jobs. On the former, workers will make big premium earnings, while on the latter they will be content with day rates. Or, attempts will

* A 25% bonus rate is assumed. If the bonus rate is ⅓ or ½ the saving, the final equation will be different.

be made to distribute time saved from one job to another to increase total premiums. There is an opportunity for favoritism by foremen in giving out tasks, and an inclination to compensate workers indirectly for jobs. This is unfair. In the setting of new task times, workers may attempt to slow up and establish "easy" times.

The Halsey plan is suited to all tasks which are estimated, roughly timed or well standardized in themselves but uncertain in accomplishment from external deficiencies.

In comparing the Halsey plan with plans based on motion and time study, it is customary to estimate 100% production with this plan as equivalent to 50% to 65% production under standardized shop conditions. When the Halsey or other plans devised for use in shops with unstandardized conditions are used in plants where task times are set on a basis of time studies, much less time will be saved by the workers. More liberal premium allowances will then need to be made.

The Rowan Premium Plan.—This was devised by James Rowan, a Glasgow manufacturer. Like the Halsey plan, which it was to improve, standard times are based on records of past performance and its installation does not disturb existing shop conditions or change methods of doing work. Task times are established for each operation or group of operations; day wages are guaranteed, and the rate per hour paid may vary with each workman. If a workman reduces the task time by a certain percentage, he gets an equal percentage of increase in his hourly rate for the time taken. The premium is a percentage of the time worked instead of the time saved as in the Halsey plan. Expressed in a formula the plan is as follows:

FORMULA FOR EARNINGS

1. Up to task:

$$\text{Earnings} = H_a R_h$$

2 At and above task:

$$\text{Earnings} = \frac{\text{Time}}{\text{Wages}} + \frac{\text{Hours saved}}{\text{Hours standard}} \times \frac{\text{Time}}{\text{Wages}}$$

$$= H_a R_h + \frac{(H_s - H_a)}{H_s} H_a R_h$$

Where H_a = Actual hours taken; R_h = Rate per hour; H_s = Standard time in hours

For a particular task, assuming that the rate per hour is \$.60, standard time 8 hours, actual time taken 6 hours, the plan would operate as follows:

$$\text{Wages} = (6 \times .60) + \frac{2}{8} \times 6 \times .60 = \$4.50$$

Mr. Rowan's premium feature was designed to protect the management in cases where the time allowed is too great, which often happens when standards are based on past performance, or possibly on mere guesses. As production is increased the premium increases, but not proportionately. The largest premium theoretically possible is equal to the time wages, which limits maximum earnings to twice the day rate. To earn this the time saved would have to equal time allowed for the task, which is physically impossible. In practice it is usually more liberal than the Halsey plan with a 50% bonus, premiums being greater up to one-half time saved, which probably covers most cases.

The operation of the premium feature in limiting earnings as output increases cools the enthusiasm of the workers and maximum efforts are seldom obtained. The complex method of arriving at wages makes the plan difficult to explain satisfactorily and less interest is taken in it. From a management standpoint the costs of administration are high, but as wages are limited there is less cause for cutting. A sort of "happy medium" may be established—fairly high wages with a fairly high production rate. Besides saving one-half the labor cost on increased volume, a saving is effected in overhead. It has the same general merits and disadvantages as the Halsey plan.

The Taylor Differential Piece-Rate Plan.—Frederick W. Taylor believed that by improving working conditions, standardizing equipment and tools, perfecting administration and providing the worker with sufficient incentive, production could be greatly increased—in some cases several hundred per cent. His differential piece-rate plan was designed to be applied to repetitive operations with the standard times based on time study after the job standardization work suggested had been thoroughly completed. It consisted in offering two different rates for the same job; a high price per piece in case the work was finished in the time allowed, and a low price if it took a longer time. If the worker accomplishes the task, but some of the work is imperfect, he may receive a still lower rate of pay. Taylor placed great emphasis upon job analysis work, the maintenance of standardized conditions and careful time study work, considering this phase of the work of even more importance in increasing output than the selection of a particular wage system.

Task times were set with exceeding care, and at a point which made a fairly hard day's work for a first-class man thoroughly trained in the doing of the task. Taylor aimed to pay high wages for an exceptional day's work, to attract the best men and eliminate the mediocre and poor

men. Management's gain was in the reduction of overhead by increased output. Rates were set so that workmen who made good earned from 30% to 100% higher than the usual wage, the per cent varying with the nature of the work and as necessary to stimulate maximum efforts.

The advantages of the system are important to men and management alike. Guesswork is eliminated in the setting of standard times. Management assumes the responsibility for shop conditions and the men assume responsibility for production under the conditions established. A desirable feature of this plan not present in the Halsey or Rowan plans is its "pulling power" toward a predetermined, fairly high standard of accomplishment. This is accomplished by providing for a sharp rise in earnings for a stated volume or rate of output. This characteristic serves to increase production averages, with resultant higher wages to workers, and lower shop overhead to management.

The disadvantages of the plan are generally considered to outweigh its merits. Failure to attain the mark set results in a double penalty, a decreased total wage as well as less pay per piece. Thus the reward is not proportionate to production. Principal interest in the plan lies in the fact that both rewards and penalties are contained in the same system. Taylor could not tolerate poor workmanship or loafing, and designed his plan to discourage them. Psychologically, however, it does not meet the needs of the average worker who may become easily discouraged. There is ample incentive for the worker to do his best, so that shop outputs should average high. Expressed in a formula the plan is as follows:

FORMULA FOR EARNINGS

1. Up to task:

$$\begin{aligned}\text{Earnings} &= \text{Number of pieces} \times \text{Low piece rate}\\ &= N_p(R_p)_1\end{aligned}$$

2. At and above task:

$$\begin{aligned}\text{Earnings} &= \text{Number of pieces} \times \text{High piece rate}\\ &= N_p(R_p)_2\end{aligned}$$

Where N_p = Number of pieces; $(R_p)_1$ = Low piece rate; $(R_p)_2$ = High piece rate

For a particular task, assuming the number of pieces as 20, standard time 60 minutes; actual time taken 50 minutes; low piece rate \$.03; high piece rate \$.04½, we would have:

Wages = 20 × .04½ = \$.90 (Rate per hour \$1.08)

With actual time 70 minutes, we would have:

Wages = 20 × .03 = \$.60 (Rate per hour \$.51½)

The plan was never widely adopted, but it has been the basis of much discussion. Its severity in weeding out all but the best workers, and the high comparative tasks set under it, antagonized labor.

The Gantt Task and Bonus Wage Plan.—H. L. Gantt was a coworker with Taylor and his wage plan is based on Taylor's differential piece-rate system. Output standards under this plan are established by time study and based on the work of the best men under the best conditions. Workers finishing the task in standard time or less receive pay for the time allowed plus a percentage of that time, varying from 20% to 50%. Only those who are well qualified earn the bonus, but day wages are guaranteed. Bonus earnings provide a strong incentive to attain the standard, but the guaranty of day wages protects the worker in event of failure.

The psychological effect of this feature was very great at the time the plan was introduced, for, in the estimation of the workers, the task standards were exceedingly high. Much of the expected increase in output was to result from improved operating conditions and methods rather than increased effort on the part of the worker, but this was difficult to explain to the satisfaction of the workers. Regarding this Mr. Gantt said:

> When it is realized that proper piece-work will, in many cases, produce at least three or four times as large an output as ordinary day work, the difficulties of putting men directly on piece-work who have been accustomed to doing work in their own way and in their own time would seem to be, and generally is, extremely difficult. While the men who are on day work usually realize that they are not doing all they can do, when they are told that it is possible to do three or four times as much as they are doing they simply do not believe it, and it is very difficult to make them accept as just, a piece rate founded on this basis; but a reward in addition to their pay rate constantly held before them will finally be striven for by some one, and when one has obtained it others will try for it. In other words, if the instruction card is made out, and a substantial bonus offered, time will do the rest.[2]

When introduced the acceptance of the bonus was optional, and various incentives were devised to arouse interest and make it a success. Foremen were paid a bonus proportional to the number of men under them who qualified for the premium, with an additional sum if all qualified. Individual production records were posted in the shops to stimulate enthusiasm, bonus societies were organized and an effort made

[2] "Bonus System for Rewarding Labor," H. L. Gantt, *Transactions of the American Society of Mechanical Engineers*, Vol. 23, p. 343.

to give distinction to the successful. Shop conditions were at first not standardized, and task times were changed from time to time as improvements were effected in machinery or methods, these being indicated on the instruction cards.

The plan permits the fixing of individual hourly rates. For each task a *regular* rate can be indicated; then workmen who are called at irregular intervals to do unusual jobs, while earning individual hourly rates will receive a bonus on the basis of the regular job rate. Thus all bonus earnings on a given job are the same, which appeals to the sense of fairness of the workers.

Labor costs are high for low production, and on a piece-rate basis for standard accomplishment or better. Production levels are fairly high under the plan because of the strong incentive offered for task attainment. A sharp leap in earnings occurs as the worker achieves the task set. The worker benefits by all the time saved. Expressed in a formula the plan is as follows:

FORMULA FOR EARNINGS

1. Up to task:

$$\text{Earnings} = H_a R_h$$

2. At and above task: (with 30% bonus)

$$\text{Earnings} = \frac{\text{Standard}}{\text{hours}} \times \frac{\text{Rate per}}{\text{hour}} + 30\% \times \frac{\text{Standard}}{\text{hours}} \times \frac{\text{Rate per}}{\text{hour}}$$

$$= H_s R_h + 30\% H_s R_h$$
$$= 1.30 H_s R_h$$

Where H_a = Actual time in hours; R_h = Rate per hour; H_s = Standard time in hours

For a particular task assuming that the rate per hour is \$.60, standard time 8 hours, actual time taken 6 hours, and bonus rate 25%, the plan would operate as follows:

$$\text{Wages} = (8 \times .60) + (25\% \times 8 \times .60) = \$6.00$$

The Emerson Efficiency Wage Plan.—Harrington Emerson's wage payment plan has proved popular with workers. Time standards are set by time study following job analysis work as in the Gantt and Taylor plans. Day wages are also guaranteed. Further, premium earnings begin to accumulate when the worker attains 67% efficiency. These are small to begin with but amount to 10% of time wages when the worker becomes 90% efficient, and 20% when he attains the standard. Above this point he gets all the time he saves plus 20% bonus for the time he works. Expressed as a formula the plan is as follows:

FORMULA FOR EARNINGS

1. Up to 66% of task:

$$\text{Earnings} = H_a R_h$$

2. Between 67% and task:

$$\begin{aligned}\text{Earnings} &= \text{Time wages} + \text{Certain bonus } \% \times \text{ Time wages}\\ &= H_a R_h + B \times H_a R_h\\ &= (1 + B)\ H_a R_h\end{aligned}$$

3. At and above task:

$$\begin{aligned}\text{Earnings} &= \text{Time wages} + \text{Savings} + 20\% \text{ Time wages}\\ &= H_a R_h + (H_s - H_a)\ R_h + .20\ H_a R_h\\ &= R_h\ (H_s + .20\ H_a)\end{aligned}$$

Where H_a = Actual time taken in hours; R_h = Rate per hour; H_s = Standard time in hours; B = Bonus

For particular problems assume that the worker has completed a 40-hour week, and has done work for which the standard time allowed is 36 hours. His efficiency is 90%. If he completes the work for which the standard time allowed amounts to 44 hours, his efficiency is 110%. At a rate of \$.60 per hour, and using bonus chart in Table 15, we have the following computations:

In the first case earnings would be:

$$40 \times .60 + 10\% \times 40 \times .60 = \$26.40$$

In the second case the result would be:

$$40 \times .60 + 4 \times .60 + 20\% \times 40 \times .60 = \$31.20$$

In practice, efficiencies are usually figured over periods of a week or possibly longer, in order to get averages and eliminate spasmodic work. The plan may be applied to groups with varying hourly rates. The guaranty of day wages and the premium earnings at low efficiencies appeal to beginners. However, this feature increases costs at low production rates, and the lack of a high incentive offered for a particular high production rate lessens the "pulling capacity" of the plan and results in lower average productions than with some others, notably the Gantt plan.

C. E. Knoeppel has modified the Emerson plan somewhat by providing an extra 5% bonus at the task point, which serves to stimulate the worker to attain it, resulting in higher average productions and lower total costs.

TABLE 15. BONUS CHART

Efficiency in Per Cent	Bonus Emerson Wage Plan	Efficiency in Per Cent	Bonus Emerson Wage Plan
66	.0000	84	.0553
67	.0001	85	.0617
68	.0004	86	.0684
69	.0011	87	.0756
70	.0022	88	.0832
71	.0037	89	.0911
72	.0055	90	.0991
73	.0076	91	.1074
74	.0102	92	.1162
75	.0131	93	.1256
76	.0164	94	.1352
77	.0199	95	.1453
78	.0238	96	.1557
79	.0280	97	.1662
80	.0327	98	.1770
81	.0378	99	.1881
82	.0433	100	.20
83	.0492		

The Bedaux Point Premium Plan.—Chas. E. Bedaux has developed a wage plan which establishes a standardized unit of work. It has proved very effective. The time unit adopted is the minute. A "point" or "B" unit is a fraction of a minute of effort, plus a fraction of a minute of allowance time, the aggregate of which is always one minute. The proportion of allowance time, which includes rest time, constitutes a varying amount of the "point" depending upon the strain induced by the task. A hard task would have a greater amount of allowance time in each "point." For an easier task the proportion of effort or work time would be increased. Sixty "points" is the normal hour's time.

In applying the plan the shop is first standardized in order to assure the worker that the same accomplishment will consistently result from the same expenditure of effort, and the number of "points" in each task is determined by time study. Base wages are set at the community level for the class of work. New men or beginners are paid, say, 85% of this amount, but are advanced to the base rate when their output reaches the standard. Those who fail to reach the standard are shifted to other jobs for which they are better qualified. Production in excess of standard is paid for at proportional rates, usually starting at 100% but gradually decreasing as the speed of the operator progresses.

Good workers may readily reach 70 to 80 points per hour, with occasional records of over 100 points. With this system in operation the

work of individuals, groups, or departments is reduced to a common denominator and may be readily compared. Individual records posted daily show what is being done and stimulate interest. As in all incentive schemes, changes in methods of doing work are destructive of morale. The plan is simple, workers are enabled to increase their earnings, and management profits by increased production and improvement in morale. Incoming orders may be estimated in "points" of work, departmental assignments made on a basis of capacity in "points," thus facilitating production control and assuring deliveries. Expressed as a formula the plan may be as follows:

FORMULA FOR EARNINGS

1. Up to task:

$$\text{Earnings} = H_a R_h$$

2. At and above task:

$$\begin{aligned}\text{Earnings} &= \text{Time wages} + \text{Earnings saved}\\ &= H_a R_h + (H_s - H_a)\ R_h\\ &= H_s R_h\end{aligned}$$

Where H_a = Actual time taken in hours; R_h = Rate per hour; H_s = Standard time in hours

For a particular task assuming the rate per hour is \$.60, standard time 8 hours, actual time taken 6 hours, and with a 100% premium rate, the plan would operate as follows:

$$\text{Wages} = (6 \times .60) + (2 \times .60) = \$4.80$$

This is similar to the 100% premium plan, except that a unit of work is established and the per cent of premium may fluctuate according to the speed of the worker.

In process work where the volume is outside the control of the workers, a process allowance may be introduced. This would vary with the volume, being greater for a smaller volume and less as it approached the normal. In effect this process allowance would keep up the worker's pay, when the volume of product is low for reasons beyond his control.

Management finds in this and other "point" systems of wage payment a valuable control device. "Point" standards for non-productive work in the shop are established and the amounts of each required for different volumes of output indicated. Costs may thus be kept in line by checking actual figures against standards. When installing a system of this kind the first essential is to improve the working conditions. By so doing the

TABLE 16. COMPARISON OF CHARACTERISTICS OF VARIOUS WAGE PLANS

(Variations in Efficiency Occur with More or Less Success in Administration)

	Time Wage Plan		Piece Rate Plan		Premium and Group Bonus Plans	Halsey Wage Plan	Rowan Premium Plan	Taylor Differential Rate	Gantt Task and Bonus Plan	Emerson Plan	Bedaux Plan	Reasons for excellence or its lack. Remarks.
	Unstandardized shops	Standardized shops	Unstandardized shops	Standardized shops								
1. Guaranteed day wages	Yes	Yes	No	Usually	Usually	Yes	Yes	No	Yes	Yes	Yes	Wages level based on community standard or below.
2. Incentive to maximum production by workers	No incentive	Fair to good	Poor	Excellent	Good to excellent	Fair	Fair	Excellent	Excellent	Good	Good	Incentives are higher pay per unit for maximum accomplishment; all earnings for time saved; immediate reward.
3. Incentive to Achieve (or excel) a carefully predetermined task	......	Fair	......	Good	Good	......	......	Excellent	Excellent	Good	Good	Incentives are higher pay per unit if predetermined task is accomplished; all of earnings for production in excess of task, immediate reward.
4. Interest and appeal to the workers	None	Good	Fair	Excellent	Good to excellent	Fair	Fair	Poor	Fair	Excellent	Excellent	Plans are weaker when it is difficult for workers to compute earnings; when pay not in proportion to output; and when workers do not receive all saving.
5. Effect on quality	The incentive to and attainment of quality standards is largely independent of the plan of wage payments used											Quality is a matter of morale, supervising and inspection. Depends on character of product, upon materials, and class of workmen employed.
6. Basis of task determination	......	Usually time study	......	Usually time study	Usually time study	Past performance	Past performance	Time study	Time study	Time study	Time study	Time study is recognized as the best method for setting tasks. However, they may be set fairly accurately by utilizing data supplied by machine tool makers combined with experience and judgment; on a basis of past performance; and by checking time on trial lots.
7. Workers rewarded for loyalty, length of service, personality, general ability, etc., as well as output	Unlikely	Possible	Unlikely	Possible	Possible	Unlikely	Unlikely	No	Possible	Possible	Possible	When time wages are a basis for computing earnings, and individual records are kept management is in a position to reward workers on this basis. Piece workers may be advanced to better paid tasks. The question is largely a matter of management policy.
8. Incentive to good management	No	Yes	No	Perhaps	Yes	No	No	Yes	Yes	No	Yes	Where standard conditions must be maintained if plan is not to fail there is incentive for good management, also where allowances are made to workers because of management's deficiencies.
9. Aid in planning and work scheduling	Poor	Fair to good	Poor	Fair to good	Good to excellent	Poor	Poor	Good	Good	Fair	Excellent	The Haynes and Bedaux plans assign work on a basis of measured capacity to produce which is an aid to work scheduling. The other systems rated "Good" tend to stabilize output at fairly high levels.
10. Pay roll computation	Simple	Simple	Fairly simple	Fairly simple	Fairly simple	Fairly simple	Very complex	Complex	Complex	Very complex	Fairly simple	Computation of payrolls with Emerson and Merrick plan may be greatly simplified by using prepared tables and slide rules.
11. Estimating labor cost in advance	Very poor	Good	Excellent	Excellent	Good to excellent	Poor	Poor	Good	Excellent	Fair	Excellent	Known costs per unit of production and plans which have a steadying effect on volume of output aid in accurately estimating labor costs.
12. Estimating overhead cost in advance	Very poor	Fair to good	Very poor	Fair to good	Good	Poor	Poor	Good	Good	Fair	Excellent	Definiteness of output facilitates estimating overhead.
13. Favorable to beginners and mediocre workers	Yes	Yes	No	Perhaps	No	Yes	Yes	No	No	Yes	No	Time wage plans inevitably favor the mediocre worker, as do incentive schemes based on past performance. In the latter case there is usually opportunity to accomplish considerably more than past performances indicate. In the Emerson plan the standard set is lower than usual. Piece work in standardised shops with a guaranteed day rate favors the beginner and mediocre worker.
14. Production cost averages	High	Fair to low	Fair to high	Low	Fairly low to low	Fairly high	Fairly high	Low	Low	Fairly high	Fairly low	Assured day wages tend to lower incentive for high production rates; while extra reward for task accomplishment tends to increase it. Costs will be lower in standardised shops.

workers, experience indicates, are enabled to produce from 10 to 30 or more "points" of work per hour without any more effort on their part.

Group Bonus Labor Payment Plans.—Group bonus plans are premium plans which make the individual's pay dependent upon teamwork. Day wages are guaranteed, but bonus earnings increase with greater production. The aim is to form into teams those who naturally work together. They may do assembly work, complete a part, or perform a series of operations. On assembly lines a group may include one hundred or more, but in production operations the greatest interest and sense of responsibility is apparent when the group numbers less than twenty, preferably not over twelve. Indirect workers and foremen may be included as group members.

As individual earnings depend upon group production, workers quickly assume responsibility for discipline, member cooperation, volume of output, and its perfection. As defective work must be made good it is to the advantage of each man to detect deficiencies on parts before added labor is performed on them. As only complete work is counted, material in process is not permitted to pile up at any intermediate point. Workers who are not qualified, who fail to cooperate, or are otherwise undesirable must answer to fellow employees as well as to the management. Members of a group have a common interest in training new men and in following the leadership of the foreman. The inexperience of beginners is not allowed to lower the efficiency rating of the groups, and they do not share in the bonus earned.

Group bonus and premium plans granting the workers 100% of savings effected in direct labor are deservedly popular with workers. Management gains in the improvements effected by job study and the higher standards set. Even unintelligent labor understands this simple wage plan and responds to the appeal of "getting all it earns."

The amount of bonus received by each workman depends upon his wage rate, and is determined by multiplying his base rate earnings by the group bonus per cent. A great deal of clerical control, counting, issuing of labor tickets, and intermediate inspections is dispensed with by keeping track of finished parts only, instead of operations, and for a group instead of individuals.

CHAPTER 27

BUDGETS

The Budget Is a Control Mechanism.—The keynote of management is control. The budget is an administrative device for controlling industrial activity and guiding it toward a defined objective. In preparing a budget the business man forecasts his business, calculates the costs of manufacture and distribution, plans his financing, and estimates profits for the period under consideration. The analysis results in the adoption of a definite, considered program of preplanned activities and cost estimates, which serves as a guide for performance and a check on accomplishment.

Formerly, the chief executive could be in touch with his departmental subordinates, counseling with them concerning policies and procedure and checking results at first hand. Today, in big business, major responsibilities are necessarily widely delegated, necessitating more formal means for making clear future plans, coordinating the efforts of executives in a common aim, and appraising accomplishment. The budget supplies this needed mechanism.

Budgeting implies planning ahead, which requires a careful interpretation of the past with judgment of the future. No business will succeed without planning, and budgeting substitutes scientific forecasting for guesswork. Business facts are too vast and too changeable to permit of exact measurement and prediction, but with experience and a rapidly developing skill in the technique of analysis very accurate forecasts are possible. The big ups and downs in the production program are easily eliminated by the use of budgets; in fact so satisfactory have been the results of its use that the value of the budget as a managerial device is unquestioned.

The present-day executive appreciates that results must have causes, and seeks to ascertain, interpret, and evaluate fundamental influencing factors which bring about existing conditions. Statistical analysis of factual data results in plans far more accurate than those shaped by experience and judgment only.

Planning Sales and Production Volume.—The volume of sales or number of commodity units to be produced will be influenced by several considerations, the most important of which are (1) production capacity,

(2) sales possibilities, and (3) finances. In periods of slow business the emphasis is placed upon increasing sales to utilize the manufacturing capacity. With improved business conditions it has been a misconception of management to think of increasing volume above normal as good business. Extra costs may easily accrue in handling peak loads. If facilities are expanded unwisely, or if buildings are constructed in periods of high building costs, a part of capital investments will need to be written off. The company treasurer will analyze the cost and long-time effect of necessary financing. These costs vary, and the possibilities of advantageous stock, bond, or note issues, and bank borrowing need to be evaluated.

The Budget Unifies All Activities.—A business budget sets a goal which represents a carefully predetermined objective for the company, makes clear to each department and individual throughout the organization the general policies and aim of the enterprise, indicates the part each is to play in achieving the goal, establishes standards of performance, and appraises results. In its preparation it brings to the aid of the chief executive the specialized wisdom of all major and minor executives. It compels all to think through plans and formulate policies which, when revised and perfected, represent a working schedule set mainly by the group which is responsible for its fulfillment. In this manner all the departments are coordinated in a common scheme of endeavor which assures unity of effort throughout the organization—in production, finance, and distribution.

The Budget Serves as a Guide.—With a budget established the chief executive has a detailed picture of expected operations before him, and in the daily direction of affairs he will recognize transactions and expenditures as part of a general plan. Without such a guide his perspective of affairs is less accurate, and he is to be pardoned if his decisions reflect faulty judgment. Whereas accounting has provided him with a post mortem of activities—a history, good or bad, of events after they have happened—budgets look ahead and seek to make the way economically safe by forethought and analysis. By the pre-adjustment of various elements of expense the business picture is brought to proper proportions. Expenditures are thus directed and controlled in amount, and losses averted.

Aims and Benefits of the Budget.—Introduced primarily to control costs and prevent waste, experience has proved budgets to be of value in many ways.

1. The formulation of a budget requires a thorough consideration and analysis of all factors influencing the business as a preliminary to the establishment of definite sales, production, and financial policies.

2. A budget combines in one coordinated plan all the activities of the business, making it possible to harmonize all departmental programs in a common effort toward a single objective.

3. Budgets translate policies into working plans, and designate definitely departmental and individual responsibilities. They outline in each instance the extent and kind of activity to be performed and the expenditures which may properly be incurred.

4. Management is provided with a chart of operations as a guide to day-by-day activities, with a means for direction and control.

5. Expectations and estimates may be constantly checked against the actual situation, permitting prompt modification and readjustment of plans if results are not favorable.

6. Estimated expenditures are indicated in total, subdivided by departments, and classified in detail within departments. Variations from anticipated rate of expenditure for any purpose will be quickly noted, the cause ascertained, and losses forestalled.

7. As all expenditures must be estimated and justified in advance, and an accounting made, less money will be wasted. The careful consideration of expenditures promotes improvements and leads to economies in operation.

8. Experience proves that the establishment of a goal or standard invariably provides an incentive to better accomplishment. Business becomes a game with all interested in lowering records.

9. Improved performance becomes a matter of record and a basis for new standards.

10. Labor employment is stabilized by producing on a more uniform schedule and filling peak sales demands from accumulated stocks.

11. Definitely scheduled requirements permit minimum inventories of raw as well as finished materials.

12. The treasurer is aided in scheduling receipts and disbursements with a reasonable degree of exactness, utilizing capital economically, and in arranging well in advance for needed loans.

13. Budgets provide bankers with a comprehensive map of proposed business activities which may be used as a basis for considering financing arrangements desired.

14. The morale of an organization is strengthened by stabilizing employment, the setting of definite responsibility with known acceptable standards of performance mutually arrived at and agreed upon, avoid-

ance of departments working at cross purposes, and knowledge that ability will show in reduced cost figures which are comparable.

The preparation of a budget evokes the ideas and intelligence of all who have responsibility for performance, widening the circle of those who participate in management. Better plans and policies result. A budget tends to curb undue optimism or pessimism of department heads by bringing to bear statistical facts and the broader perspective of major executives. It is to business what the navigator's chart is to the ocean pilot.

The Budget Executive.—Experience demonstrates the wisdom of centering the responsibility and authority for the administration of budgets with an officer of high rank. Very often the chairman of the board, or the president, is designated to be in charge; while in other instances the treasurer, comptroller, or general manager receives the assignment. The general manager has unquestioned authority with the heads of functional departments in requiring estimates and reports, and is in a position to settle any controversies which may arise with regard to coordination of departmental activities and estimates. The other officers named are qualified by an intimate understanding of the affairs of the company as a whole and the similarity of the work involved with regular duties. The comptroller, particularly, will be skilled in the preparation of statistics, and the interpretation and judgment of data. Much of the actual work to be performed, and all the detail duties, will be handled by a staff assistant of the official designated as budget officer.

The executive in charge of the budget should be assisted by a committee composed of heads of the principal divisions of the business, such as the sales manager, production manager, comptroller, treasurer, and possibly the personnel manager.

Methods of Determining Budget Figures.—For a budget to be successful it must be sold to the organization, and have the respect and cooperation of all concerned. A budget may be arbitrarily imposed from above, or it may be allowed to develop from below simply and logically through the efforts of the organization as a whole. The former plan is likely to prove unsatisfactory, and fail; while the latter procedure will establish and maintain goodwill. The effectiveness of the budget is dependent upon the data and figures which give it form, and these are of greatest worth when supplied by those on the "firing line," who in turn are responsible for performance. Likewise, building up from below stimulates the rank and file of subordinate executives to thinking in terms of management and gives them an appreciated opportunity to participate in it. This situation arouses interest and enthusiasm.

Plans for Budget Procedure.—One plan of budget procedure places the greater share of responsibility and the initiative in the hands of the budget officer, as for instance the comptroller. The budget committee decides upon a sales quota, considering marketing possibilities, and production and distributing costs. The committee has in mind the profits which can reasonably be expected under prevailing business conditions, or are desired, considering the invested capital; also estimated selling prices, and manufacturing costs.

With these data, the comptroller, utilizing the accounting data and statistics available in his department, estimates operation costs for the principal departments of the business. These figures submitted to department heads, together with the proposed schedule of operations, are subdivided into division and section estimates and placed in the hands of the executives in charge. Detailed estimates of the expenditures called for are prepared by these individuals as a check on the allowances made. Informal conferences with superiors, including the budget executive, may be necessary in efforts to reconcile conflicting estimates, differences in judgment, or secure any necessary changes in appropriations. As agreements are reached, section and department estimates are consolidated into division estimates, and these in turn summarized by the budget officer.

The budget program then meets its final test at the hands of the budget committee. Are all plans as proposed sound? Can they be realized? Are any changes suggested in the light of new developments in the business situation? Have any necessary changes in estimated costs affected anticipated profit margins? What further tests can be applied to the wisdom of the program outlined? From the deliberations of this group there will finally emerge an agreed upon working program, which when approved by the chief executive will constitute the budget for the ensuing period.

At the initiation of the budget procedure it is desirable to call a group meeting of all those who will be active in the preparation of estimates, at which time the objectives of the management may be presented, the procedure of preparation outlined, and support won to the plan of action. Further general meetings should be held from time to time, especially when the departmental budgets are nearing completion, to assure that departmental plans properly interlock, and for discussion of the program in its entirety.

Another and perhaps more usual plan adopted is to submit proposed production and sales programs to the respective departments and ask them to prepare expense budgets. This is done on a basis of previous budget figures and experience, modified in accordance with prevailing conditions. These departmental and division expense budgets are then

gone over in conference with the budget officer and budget committee, and finally evolve into an acceptable working program. Both plans of procedure finally result in figures agreed to by all concerned. Emphasis in one direction or another will be suggested by its effect upon expediting results and influence upon morale and sense of responsibility for attaining objectives.

Classification of Expenses for Budget Purposes.—There are two classes of expenses to be considered in budget estimates:

1. Fixed expenses which do not change greatly with volume of business.
2. Variable expenses which are affected by or are proportional to volume of business or work done.

Department heads within a plant have control only over variable expenses. For this reason budgeting should be along lines of responsibility, and fixed or overhead expenses budgeted at their sources. An operating department is not responsible for cost of insurance, taxes, depreciation that is charged for accounting purposes, heating or air conditioning, and should not be budgeted for them. Thus, budgeting expense may not coincide with accounting charges because of the difference in distribution.

Checking the Budget.—The periodical compilation of costs will reveal the actual results for comparison with budget estimates. These reports should entail little extra expense, if any, for the figures required are those customarily accumulated for accounting purposes. Copies are supplied to the general manager and departments interested. Any appreciable variations from the anticipated situation may be checked to ascertain causes, and the necessary steps taken to remedy deficiencies.

When first installed a system of budgets may prove unreliable and results may vary considerably from their estimates. With experience, however, closer approximation results and the desired control is achieved.

Operating Ratios.—Table 17 provides a suggestion for the presentation of operating relationships. The figures will vary with the volume of business and the time, but they are no less significant on that account.

Talon, Incorporated, uses the profit and loss budget as a master control. "If we know the anticipated sales income, the minimum profit desired, and the resultant taxes, it is evident that a limit is established beyond which selling, administrative, and manufacturing expenditures cannot go without seriously curtailing capital return.

"Making use of basic information concerning past cost records, present

cost trends, and anticipated cost reductions, we then break down the total expenditure into the various cost elements—selling expense, administrative expense, direct labor, direct material, factory overhead, etc.—and corresponding limits are established for each. We find a picture of the long-term trend in each of these income and expenditure elements, presented graphically, to be of great value in establishing these limits. . . . The direct result of this analysis is the establishment of our profit and loss budget for the coming year."[1] See Table 17.

TABLE 17. FUNDAMENTAL OPERATING RELATIONSHIPS
PROFIT AND LOSS BUDGET FOR YEAR, ...

NET SALES
Direct Material
Direct Labor
Overhead
Total Expenditures
Inventory Increase or Decrease
COST OF SALES
% to Sales
GROSS PROFIT
% to Sales
Selling Expense
% to Sales
Administrative Expense
% to Sales
TOTAL ADMINISTRATIVE AND SELLING EXPENSE
% to Sales
OPERATING PROFIT
% to Sales
Other Income and Expense
NET PROFIT BEFORE TAXES
% to Sales
Provision for Taxes
% to Sales
Provision for Contingencies
Total Provisions
NET PROFIT
% to Sales
Dividends
% to Sales
NET PROFIT TO SURPLUS
% to Sales

[1] "Budgeting for Profit," by P. K. Poulton and P. H. Goldsmith, *Factory Management and Maintenance,* Vol. 97, No. 9, p. 52.

A proper relationship of these items may be established for any business. Then, if cost of sales or net profit is out of balance, the actual ratio will be abnormal and attract attention to the situation. A further development of these ratios might show an incorrect relationship between direct and indirect labor and thus indicate an inadequate use of mechanical handling equipment. Each ratio given is a guide and a signal.

TABLE 18. COMPARATIVE RESULTS OF OPERATIONS FOR DIFFERENT SALES VOLUMES

Sales (thousands of dollars)...	500	600	700†	800	900	1000	1100	1200‡	1300	1400	1500	1600	1700	1800	1900	2000
Sales (percentage)........	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Materials......	40.3	39.4	38.5	37.8	37.2	36.7	36.7	36.7	36.7	36.7	36.7	36.4	36.1	35.8	35.5	35.2
Direct Labor .	28.0	27.5	27.0	26.5	26.0	25.5	25.5	25.5	25.5	25.5	25.5	25.0	24.5	24.0	23.5	23.0
General Factory Expense ..	20.0	19.0	18.0	17.0	16 5	16.0	15.5	15.0	14.5	14.0	13.5	13.0	13.0	13.0	13.0	13.0
Cost of Sales .	88.3	85.9	83.5	81.3	79.7	78.2	77.7	77.2	76.7	76.2	75.7	74.4	73.6	72.8	72.0	71.2
Gross Profit on Sales	11.7	14.1	16.5	18.7	20.3	21.8	22.3	22.8	23.3	23.8	24.3	25.6	26.4	27.2	28.0	28.8
Selling Expenses	8.0	7.7	7.5	7.3	7.1	7.0	6.9	6.8	6.7	6.6	6.5	6.4	6.3	6.2	6.1	6.0
Selling Profit ..	3.7	6.4	9 0	11.4	13.2	14.8	15.4	16.0	16.6	17.2	17.8	19.2	20.1	21.0	21.9	22.8
Administrative Expense	10.0	9.0	8.0	7.0	6.5	6.0	5.9	5.8	5.7	5.6	5.5	5.4	5.0	5.0	5.0	5.0
Operating Profit	6.3*	2.6*	1.0	4.4	6.7	8.8	9.5	10.2	10.9	11.6	12.3	13.8	15.1	16.0	16.9	17.8

* Loss. † The break-even point is at 58 per cent of a normal capacity estimated at a sales volume of $1,200,000. ‡ Normal production capacity

Table 18 gives comparative results of a firm's operations for different sales volumes. The compilation of such a table provides budget data, which as time passes increase in dependability and value. It will be noted that the various expenses do not vary proportionately with production increases. Data of this kind offer opportunity to readjust budget figures in harmony with actual conditions.

The Sales Budget.—Sales volumes are influenced greatly by the intensity of the selling effort, prices quoted, and the market. They vary with the season, with general business conditions over longer periods, and with accidental happenings. These latter causes, which include acts of providence, strikes, style changes, etc., can seldom be foreseen or anticipated.

Sales managers alert to note local conditions affecting dealer demand may learn much through salesmen's reports, local papers, credit journals, crop reports, and bank bulletins. The recognition and interpretation of

forces affecting business over national areas require a broader perspective, and an appreciation of the nature and causes of business cycles. In the main budgets are built on past experience. To produce a dependable forecast requires a combination of experience, business acumen, statistics of the general situation, and a thorough knowledge of the facts pertaining to the business. The budget committee supplies this broad-gauge intelligence which is so necessary if predictions are to prove dependable.

As sales quantity budgets pass from those interested primarily in distribution to the budget officer or budget committee they are viewed with greater perspective and from the manufacturing viewpoint, and with greater appreciation of the general effect of the proposed program on the company's welfare. Increased sales do not necessarily add to profits.

The Sales Expense Budget.—Experience shows that selling expenses may be estimated within 1% of the actual. This is accomplished by a predetermination of the ratios of selling expenses to sales volume that will permit profitable operation, setting up a ratio in the budget that will permit a profit to be gained, and then making sure, by a close follow-up of subsequent activities, that this budgetary estimate is met. A tendency to spend expense appropriations without reaching sales quotas must be constantly guarded against.

Sales expenses cannot be decreased in proportion to the falling-off of sales, but the wisdom of increasing sales effort at such times is to be questioned. If dealers are justified in withholding orders the best policy may be to decrease selling effort and sales costs. Variations from accomplishment with budget estimates should provoke a careful study of causes and perhaps result in a revision of sales policy to conform to the existing situation.

Manufacturing Departmental Budgets.—Production quota figures to the operating departments may be accompanied by expense estimates, or these may be prepared by the individual department as previously suggested. In event the latter plan is used previous budget figures and experience will serve as a guide. Estimates so prepared are subject to careful scrutiny by department heads and budget officers, and requests for revision are made as circumstances warrant. In this way the final budget arrived at is the joint effort of the budget officer and the operating departments, but must in a true sense represent a self-set goal of the latter. Certainly greater responsibility for results can be insisted upon when this is the case.

Quantity estimates are analyzed and broken down by department heads until the work for each divisional supervisor or foreman is planned in detail. Expense estimates are then prepared by these men,

DEPARTMENT 10-61 BUDGET

	Line No.	ANNUAL BUDGET	JANUARY Mo.	FEBRUARY Mo.	FEBRUARY Acc.
40 Piece Work	1				
41 Day Work	2				
42 Job Order	3				
	4				
TOTAL DIRECT LABOR	5	15,000	1,250	1,200	2,450
	6				
50 Supervision	7	3,000	250	230	480
51 Clerical	8	100	8	5	13
52 Set Up	9				
53 Maintenance	10				
55 Misc. Indirect	11	100	8	5	13
56 Overtime	12	100	8	5	13
57 Third Shift Differential	13	300	25	15	40
58 Retainer	14	100	8	5	13
59 Vacation Time	15	300			
60 Machine Down Time	16				
63 Call Time	17				
65 Wait for Work	18				
69 Special Departmental	19				
	20				
TOTAL INDIRECT LABOR	21	4,000	307	265	572
	22				
70 Tool & Die Parts	23	300	17	15	32
71 Supplies	24	200	17	15	32
75 Printing & Stationery	25	200	17	15	32
76 Travel and Entertainment	26	50	4	5	9
91 Repairs & Maintenance Mat'l	27	300	30	20	50
92 Small Tools	28	50	5	5	10
95 Payroll Taxes	29	1,000	80	75	155
98 Misc. Expense	30				
	31				
TOTAL SUPPLIES & EXPENSE	32	2,000	170	150	320
	33				
TOTAL CONTROLLABLE OVERHEAD	34	6,000	477	415	892
	35				
PRO-RATES:	36				
Management	37	5,000	400	350	750
Tool Rooms	38				
Maintenance and Electrical	39	3,000	250	200	450
Machine and Tool Repair	40	2,000	160	130	290
	41				
TOTAL FACTORY OVERHEAD	42	16,000	1,287	1,095	2,382
	43				
DIRECT MATERIAL	44	219,000	17,963	17,205	35,168
	45				
GRAND TOTAL EXPENDITURE	46	250,000	20,500	19,500	40,000
	47				
UNIT COST PER TAPE FOOT	48	.09370	.09370	.09380	[illegible]
UNIT COST PER EQ. FASTENER	49	.26720	.26700	.26700	.26700
	50				
PRODUCTION - TAPE FEET	51	2,640,000	222,000	212,850	434,850
DIRECT LABOR HOURS	52	22,416	1,892	1,812	3,20[illegible]
OPERATING DAYS	53	282.0	23.8	22.8	46.6
PRODUCTION PER OPR. DAY	54	93,617	93,617	93,617	[illegible]
D. L. HOURS PER OPR. DAY	55	79	79	79	79
PERCENTAGE OF CAPACITY	56	63	63	63	63
AVERAGE HOURLY EARNINGS	57	.62	.62	.62	.62
	58				
	59				
	60				

Budget Department RLR:CHP

Figure 132. A Typical Annual Departmental Budget for a Direct Production Department

(From "Budgeting to Cut Unit Costs," by P. K. Poulton and P. H. Goldsmith, *Factory Management and Maintenance*, Vol. 97, No. 10)

which after review and correction by department heads are consolidated into a department budget. In like manner further progress is made until one set of figures represents the combined estimate of operating expenses for the proposed program.

Direct costs which vary with output, such as wages under the piece-work plan, are readily summarized. Indirect costs may be estimated from experience at previous corresponding periods or during the previous month. Another method is to make calculations on a basis of units of output, as per pound, etc., or on a basis of productive man-hours.

Man-hours of productive labor........	4,000	5,000	6,000
Expense rate per unit.................	$ .45	$ .41	$ .39

Expense rates will vary somewhat at different seasons due to taking inventories, extra help during vacation periods, etc. They will not vary directly with productive labor hours because supervision, quantities of supplies, stationery, etc., do not so vary.

One large company began its budgeting work with simply an analysis of departmental expenses along the lines on which budget estimates would be prepared. These figures in the hands of department heads and foremen showed what had been accomplished, stimulated interest, and provided a bull's-eye at which to aim. Cooperation followed as a matter of course. Experience proved educating to both the budget and operating departments, resulting in improved budgeting technique and continued lowering of operating costs. Figure 132 provides a typical annual departmental budget for a direct production department. Anticipated expenditures are shown by months; also the year-to-date total. Periodically, reports are prepared showing expenses as incurred in comparison with budget estimates.

Varying volumes of production affect expense totals, and it is very desirable to know the amount of expense which should be incurred with varying outputs. With a knowledge of past costs, expenses by departments for varying outputs may be calculated. Figure 133 shows a departmental cost-volume schedule.

In a tire plant figures have been worked out for each kind of expense and for different outputs, the estimated unit expense changing with every fluctuation of 500 tires from normal production. When an output schedule is given to a foreman he is supplied with unit data applying to the quantity specified. (See Table 19.)

TABLE 19. FORM FOR FOREMAN'S BUDGET

Foremanship per tire	Inspection per tire	General Labor per tire	Contingencies per tire	Total Cost per tire	Total Cost per day
$ .00291	$ .01123	$ .01468	$ .00288	$ .03170	$ 79.25

Plant 61
Department Sewing
Number 10
Foreman John Jones

DEPARTMENTAL COST—VOLUME SCHEDULE

(Allowances per operating day at varying levels of activity)

ACTIVITY INDEX	PER CENT CAPACITY 10		20		30		40	
Production in Tape Feet	1,470		2,940		4,450		5,940	
Prod. in Equiv. Fasteners	520		1,040		1,560		2,080	
BASE - Actual Direct Labor Hours	12.5		25.5		37.5		50.5	
ACCOUNT	MAN HOURS	$	MAN HOURS	$	MAN HOURS	$	MAN HOURS	$
DIRECT LABOR 40 Piece Work								
41 Day Work								
42 Job Order								
TOTAL DIRECT LABOR	12.5	7.80	25.5	15.60	37.5	23.45	50.5	31.30
INDIRECT LABOR 50 Supervision	10	9.60	10	9.60	10	9.60	10	9.60
51 Clerical	1	.50	1	.50	1	.50	1	.50
52 Set-up								
53 Maintenance								
54 Repairs - Machines								
55 Miscellaneous Indirect		.40		.40		.40		.40
56 Overtime								
57 Third Shift Diff.						.20		.50
58 Retainer		.20		.20		.20		.20
60 Machine Down Time								
61 Trav. & Quality Insp.								
63 Call Time								
64 Repairs - Tools & Dies								
65 Wait for Work								
69 Special Departmental								
TOTAL INDIRECT LABOR		10.70		10.70		10.90		11.20
INDIRECT SUPPLIES and EXPENSE 70 Tool & Die Parts Repl.		.10		.20		.30		.40
71 Supplies		.15		.25		.40		.50
75 Printing & Stationery		.05		.10		.20		.25
76 Travel Expense		.05		.05		.05		.05
91 Repair & Mtnc. Material		.10		.15		.20		.25
92 Small Tools		.04		.06		.09		.11
95 Payroll Taxes		.40		.80		1.15		1.60
98 Miscellaneous Expense								
TOTAL INDIRECT SUPPLIES & EXP.		.89		1.61		2.39		3.16
TOTAL CONTROLLABLE OVERHEAD		11.59		12.31		13.29		14.36
GENERAL OVERHEAD PRORATES Maintenance & Elect.		5.90		5.90		5.90		5.90
Tool Rooms								
Management		14.25		14.25		14.25		14.25
Machine & Tool Repair		5.10		5.10		5.10		5.10
TOTAL DEPARTMENTAL OVERHEAD		36.84		37.56		38.54		39.61
DIRECT MATERIAL		124.50		248.40		373.50		498.50
GRAND TOTAL EXPENDITURE		169.14		301.56		435.49		569.41
UNIT COST PER TAPE FOOT		.11510		.10260		.09790		.09590
UNIT COST PER EQUIV. FASTENER		.32530		.29000		.27920		.27380

Budget Department RLR:CHP

Figure 133. A Cost-Volume Schedule Which Shows What Expenditures Should Be at Various Levels of Production

The volume of production planned for each month will be influenced by the sales schedule, considering benefits to be derived by smoothing out the production curve and accumulating stocks against peak demands. For example, an automobile manufacturer needs to deliver, in the month of April, 12% of the year's sales volume. To produce this in one month would require a capital investment in plant and equipment of nearly double the amount necessary to produce the 8.3% necessary on a level production basis. Fixed charges would be excessive. The labor problem would be very difficult, especially in securing skilled workmen. Items influencing seasonal operation are style changes, obsolescence, and financial inability to carry investment involved in warehousing large quantities of finished goods.

Budget figures for production departments are usually expressed in units of the various items produced, although in some industries, bulk, tonnage, or value figures may measure the output more accurately.

The Purchasing Department Budget.—As soon as the manufacturing quota is set, and the schedule of production planned, the purchasing department may analyze the program in terms of kinds of materials needed, quantities, and deliveries required. In large organizations this analysis may be made by a materials department or the planning room staff of the production department. These data translated into money values are made available to the treasurer. With information of the volume of work to be handled in this department, the purchasing executive may prepare an expense budget with accuracy.

The Personnel Department Budget.—The preparation of the budget provides an opportune time for this department to plan its activities and expenses, and enables them to be checked and held within reasonable limits. These will be discussed in executive committee meetings and agreed upon preliminary to the preparation of an expense budget for the department. Following the beginning of the budget period a monthly report should be required giving the number of employees, and contrasting the estimated and actual expenses by activities and per capita.

Labor needs are indicated by production plans and may be arranged for. Seasonal demands require extra help, and when these may be quite definitely anticipated a potential reserve of satisfactory labor may be built up subject to call. The number of apprentices and those in training classes will be influenced by future requirements, especially when men need to be trained within the plant.

One of the outstanding advantages of budgeting is in stabilizing production and employment. This reacts to the direct benefit of the personnel department as the improved morale makes possible the greater effective-

ness of its work to increase efficiency and maintain a contented labor staff. The department will be helpful to the operating departments in supplying data with respect to changes in wage scales and scarcity of trained men in various trades due to demands elsewhere.

Other Auxiliary and Service Department Budgets.—In general the setting of production and sales quotas forms a basis for the preparation of auxiliary and service department budgets as above outlined and for stores, shipping, engineering, power, maintenance, general office, advertising, administrative and other departments.

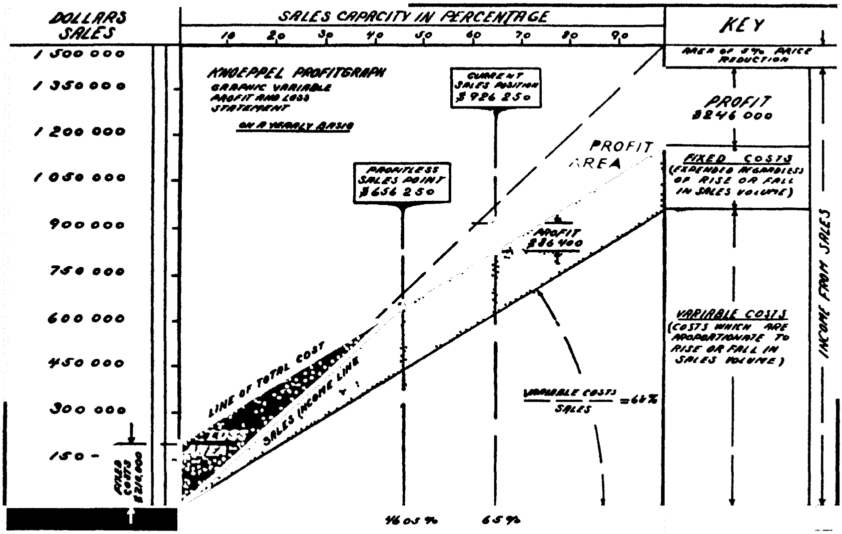
The Financial Budget.—The financial budget is not a department budget, but a consolidated financial map of the activities of all departments. It comprises two estimates: one for receipts and one for disbursements. The former provides data of the anticipated income from each source for each month. The latter indicates the purpose of expenditures, amounts, and when required.

The two foregoing cash statements provide the treasurer with a picture of financial requirements well in advance of actual needs. They give him the total figures for income and outgo and enable him to determine what gross and net profits are expected to be, and data on needed reserves for taxes and dividends. A study of expense figures also aids in disclosing possible uneconomical uses of working capital. Costs of this kind accrue from idle or semi-idle plants, unbalanced or excessive inventories, slow processing, delayed deliveries, slow collections, and the practice of warehousing customers' orders gratis.

The treasurer's financial analysis of proposed plans will aid the budget committee in judging their soundness, and very probably suggest modifications before final adoption. Upon the capital available will depend the volume of business which can be handled profitably and safely. Bank credit is rather definitely limited, even to successful firms. A minimum volume of sales planned for should yield fair returns; to attempt to handle a possible maximum volume may introduce risks made apparent by the treasurer's budget, which are preferably not to be incurred.

Flexible Budgets.—In order to note the effect on profits of various sales volumes the flexible budget has been evolved. The Knoeppel Profitgraph, Figure 134, illustrates this. For any volume of sales the income and resulting profit or loss is shown. What the company needs to do to maintain its position is clearly evident.

Using a chart of this kind the profit possibilities may be analyzed in advance. A sales income line is drawn in accordance with estimates. Next a vertical line is drawn at the point of estimated sales in per cent



(Courtesy of The Knoeppel Co.)

Figure 134. The Knoeppel Profitgraph

of capacity. On this line, downward from the point of intersection with the sales income line, is measured the desired or necessary profit. Through this latter point is drawn the "line of total cost." (See chart.) Fixed and variable costs are then indicated as shown in the chart. If analysis shows that costs as represented by the graphs cannot be realized plans may be adjusted before embarking upon the program. With this technique profits will be a planned result, not merely a chance result.

Interest of Firm's Banker in the Budget.—When negotiating loans, the company's bankers will be interested in the financial chart picturing the course of business during the period to be covered by advances. Bank officials may even ask for copies of the financial budget and for the comptroller's periodical reports of actual accomplishment.

Length of Budget Period.—The length of the budget period will depend upon the business, its financing arrangements, and the worth of data available for guidance in forecasting.

In lines of business requiring production throughout the year for a sales season of short duration, it is necessary to have a budget period one year in length. A general rule is that the budget must cover a complete cycle of operations—production, selling, and collection. Where there are well-defined seasons, as in the garment industry, the budget may logically be for a shorter period to correspond. Uncertain market

conditions suggest short budget periods with frequent opportunity to adjust plans. For example, an auto accessory manufacturing company prepares a budget on a quarterly basis. In businesses where the turnover is quick and the volume fairly stable, the budget period may be one month in duration.

Some companies prepare a tentative budget for a fairly long period such as a year, with definite, detailed budgets for a shorter period. This idea may be combined with the plan of adding a future month to the schedule as each month goes by.

In contracting and similar activities, budgets should be for the time required to complete the project. Financial arrangements obviously need to extend over the construction period, as the company's investment increases until completion and acceptance of the project. Definite schedules of progress, including money to be received on account as well as anticipated expenditures, may profitably be made for intervening periods. These will provide a check on progress, costs, and estimated profits, and likewise call attention to leaks and wasteful expenditures.

Banks favor budgets on a basis of the industry's business cycle, realizing that with one complete turn of the business wheel, i.e., manufacturing, selling and collection, a company should be in a position to "clean up" its bank paper. Bank loans are not intended to supply working capital needed permanently in the business.

Budgets Are Adjustable.—An organization is not committed to an accepted budget program for the length of period designated. Budgets are merely plans for action in accordance with conditions as they are expected to be. If conditions change, or the wisdom of following the plans made is for any other reason questionable, executive action should modify them as seems best. This suggested action is no different from what would actually take place without a budget.

As activities progress for which expenditures are budgeted, expenses are necessarily paid. Variations from the anticipated amounts of expenditure simply provide a basis for inquiry and any necessary adjustment. Control is thus assured. Those responsible for expenditures are not relieved of responsibility when the extent of budgeted activities is changed, for expense figures may be adjusted accordingly.

Scope of Budgeting.—There are few limitations to the application of the budget idea in business. Budgets may be made applying to all departments and all details of a business. Time studies budget the use of machines and labor time, and depreciation allowances are a form of budgeting. Successful application of the idea may be made in connection with (1) waste, (2) supplies, (3) maintenance, (4) labor turnover,

(5) "seconds," or defective product, (6) departmental schedules of production, and (7) indirect labor expense. A tire company reports success in reducing costs for these items as follows:

	Reduction Per Cent
Waste	25
Supplies	10
Maintenance	25
"Seconds"	30
Repairs on product	50
Indirect labor expense	40
Labor turnover (per month)	15

An automobile company by an intensive study set standards for non-productive labor, scrap, supplies, etc. Superintendents readily achieved the goal set and further decreased the ratio of non-productive to productive workers. Scrap loss per car was cut over 50%. This general program was largely instrumental in effecting a saving of $3,500,000 in nine months.

Limitations of the Budget.—A budget is an instrument for the use of management. It is not management, nor is it any better than the judgment of the executives who contrive it. It should not prove a hindrance to the exercise of individual initiative, but an aid in exercising control after the formulation of a formal policy and program. Those in authority should realize that unexpected developments call for readjustment of plans, and since the future is too vast and too changeable to be measured with exactness there should be ample opportunity for and expectation of revision as the need arises. With practice in budgeting this need will probably diminish. Business cannot be mechanized by any device, nor can anything be substituted for the thinking, reasoning mind of the executive.

Cost of the Budget.—The cost of budgets is small. Forecasts must be made and work planned in any event. For this reason some corporations do not permit departmental expense in making up budgets. A packing company with annual sales of $900,000,000 has only six or seven people in the budget department. Forecasting business conditions does entail the preparation of statistical data, charts, and business information, but in the aggregate the added expense for doing this is small. Plans properly made prevent confusion later and expedite performance.

Results of Budgeting.—The results of budgeting demonstrate its value in forecasting business accurately, indicating leaks, and reducing costs.

The Fairbanks Company reports that in the first three months of the year the manufacturing costs exceeded the budget allowance by only 2.18%. This was during a period of unsettled business conditions. A company manufacturing building equipment produced to customers' specifications, has been able to forecast its sales over a period of ten years with an accuracy of 85%. For the last two years they have been able to obtain 95% accuracy. Canada Dry Ginger Ale, Inc., has found that with their cost accounting methods it has been possible to estimate production costs with a variation of considerably less than 1/10 of 1%.

Eli Lilly & Company in establishing sales quotas finds that actual sales vary from the estimates within one or two per cent each year. The Andrews Steel Company, Newport, Kentucky, has employed a plant and maintenance budget for several years. Through the use of this budget the firm has succeeded in reducing labor, material and overhead costs from 7% to 12% below the budget allowance by improving the operating efficiency of their departments. Budgets increase in effectiveness each year, and estimates are more accurately made. Budgeting of overhead expenses in manufacturing has brought about 30% reduction.

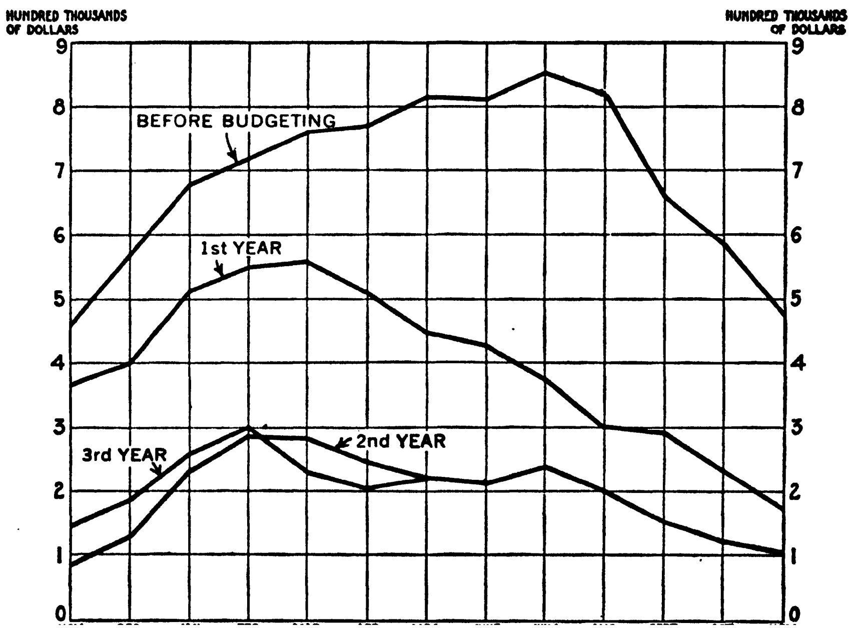


Figure 135. Effect of Budgetary Control upon Inventories

Carey E. Tharp says: "Production forecasts (annual) within 10% of accuracy are readily possible in the textile industry." Other authorities skilled in budget making consider 5% sufficient allowance for error in monthly estimates of sales, expenses, or profits, if they are not to bring discredit upon those who compile them.

Figure 135 shows the results of budgeting as applied to control of inventories. The steady increase in effectiveness resulting from experience is also indicated clearly.

Accomplishment Without a Budget.—A large manufacturer in the tractor and equipment field does not use the orthodox budget procedure. Forms with estimated expenditures for various purposes are used to establish production standards, and all parts made are analyzed in detail as to material, labor, and overhead costs. Standards are set from these data. Those responsible for production activities proceed to get results as effectively as possible, knowing that costs incurred will be analyzed and evaluated by the cost department. From time to time individuals are advised of the effectiveness of their accomplishment, and ways and means of bettering the situation discussed. This simplified procedure works in this instance.

CHAPTER 28

PURCHASING

The Purchasing Function.—Industry pays out for materials of manufacture over 50¢ of each dollar it receives, on an average. It has been estimated that gross sales must be increased $10 to compensate for each dollar of waste in purchasing.[1] Purchasing effectiveness also influences the cost of manufacturing and satisfaction to customers. In some industrial lines where production costs vary but little among producers, profits are dependent largely upon successful purchasing.

The objectives of good purchasing are: (1) to purchase the required quantities and qualities of necessary materials; (2) to secure deliveries of materials as needed; and (3) to purchase at the lowest total cost, consistent with obtaining the required quality and satisfactory service.

Centralization of Purchasing.—Purchasing may be done by each department taking care of its own needs or by a centralized purchasing department doing the buying for all departments of the company. The centralized purchasing department capably operated should be best able to keep in touch with the needs of different individuals, the market conditions, the available vendors, shipping conditions, and all other things which should be known if purchasing is to be performed most advantageously. Some of the advantages of centralized purchasing are summarized as follows:

1. A skilled purchaser may be placed in charge.
   - (a) He devotes full time to the business of buying.
   - (b) He keeps informed on market trends and up-to-date purchasing methods.
   - (c) He substitutes scientific methods of market analysis for mere guesswork.
   - (d) Careless order placing by novices in the art of buying is eliminated.
2. Responsibility for results is fixed and an opportunity afforded to check results.

[1] "Purchasing," by E. T. Gushee and F. A. Compton, *Handbook of Business Administration,* Sec. 3, Ch. 12.

3. Savings are effected in time, efforts, and cost of operation over separate departmental agencies.
4. Greater competition, better prices, and more prompt deliveries are secured on larger orders representing the aggregate needs of the entire organization.
5. Efforts toward simplification and standardization:
   (a) Reduce inventories and unnecessary variety in stocks.
   (b) Permit the application of effective tests to determine quality.
   (c) Lead to equipment standardization.
   (d) Stimulate the marketing of better materials in greater volume at lower prices.
6. Central supervision over:
   (a) Disposal of surplus stock by transfer between departments, or by sales.
   (b) Storage and distribution of production commodities.
   (c) Checking deliveries and adequate inspection.
7. Better fiscal supervision over expenditures by close cooperation between finance and purchasing departments.
   (a) Cash discounts saved by prompt approval and payment of invoices.
   (b) Duplicate payments eliminated by double check on invoices.
   (c) Profits increased through orders in advance of need on favorable markets when finances will permit.
8. Time and amount of purchases regulated by advance sales forecasts, by information of stock on hand in raw materials and finished products, and by knowledge of market trends.
9. Uniform buying policies and vendor relationships may be established and maintained.

It will continue to be true that in many small concerns producing only a few simple or standard products adequate purchasing talent and intelligence will be found among department heads and officials, men who can exercise this function without detracting from their value in other capacities. Centralized control and approval of orders placed may be all that is justified or desirable in these instances.

Place of the Purchasing Department in the Organization.—Just where in the organization the responsibility for purchasing should be placed is a problem with varying answers. In a few industries purchasing and selling are closely related. This is true when the time interval

between these functions is short, the manufacturing operations of a minor nature, or the chief value of the product is in the purchased material. Examples are the mercerizing of yarn, flour milling, and certain branches of the garment industry making highly styled goods.

In some lines, such as the cotton goods trade, production costs are much the same for competitive plants, and profits are largely dependent upon prices paid for raw materials. Buying of a speculative nature which is necessary in certain industries, because of the rapid movements of their raw material markets coupled with a high ratio of raw material costs to total costs, should be under the control of a major executive who is in a position not only to know market conditions, but also to be thoroughly familiar with the financial policy and program of the firm. Price protection by hedging operations in the open market is sometimes possible as in the case of raw rubber and many imported products.[2]

Such purchases greatly influence profits, necessitate large money outlays, yet may occur so infrequently as not to be burdensome as a matter of routine. A company treasurer might well handle such speculative buying.

In very large organizations purchasing is usually administered by a vice president, so important is the work considered and so great are the possibilities for saving and the exercise of business judgment and ingenuity. In smaller concerns the purchasing department frequently is subordinate to the general manager and on the same level as the superintendent of production, the personnel manager, comptroller, and sales executive.

Several manufacturing companies, particularly those of a small or medium size, centralize the purchasing function, but place it under the control of one of the major departments, such as manufacturing. Most purchases are of raw materials, parts and supplies used in plant operations, so there is a valid reason for centralizing all purchasing in the manufacturing department. Similarly, when the engineering department draws up detailed specifications for products obtained from the outside, it may be considered wise to give that department charge of all purchasing.

[2] Explanation of hedging operations. A flour milling company buys large quantities of wheat during the harvest season to assure itself of supplies throughout the year. Its margin of profit is the difference between the price paid for the wheat and the price at which it resells its products, less operating expenses.

When a milling company buys wheat during the harvest period it sells short a corresponding amount of wheat in the future market (agrees to deliver wheat at a future date). As it uses up its inventory and sells its products the wheat sold in the futures market is "bought in." The future market operation involves no actual transfer of grain but provides price protection. If wheat rises in price after the milling company has made its hedge, it loses money on the future transaction but makes it up through an increase in the value of inventory.

The weakness of a buying division subordinate to the manufacturing department lies in the tendency to make purchasing a routine matter of placing orders with customary sources. Emphasis is placed upon production requirements. If placed subordinate to the stores department, investment in stocks is likely to be stressed unduly; if under the engineering department, quality may be overemphasized. When the department functions independently these factors are more likely to be kept in proper balance, and the possibilities for saving inherent in specifications, standard tests, competition, substitution of materials, opportune buying, discounts and buying skill, fully realized.

Qualifications of the Purchasing Executives.—The purchasing executive must deal with the keen minds of highly trained and successful selling organizations, and must be capable of analyzing and judging proposals and representations made to him. Moreover, where the seller must know one or a few products expertly the buyer must have an intimate understanding of many. He should, therefore, be a broad-gauge individual possessed of training in economics and world affairs, a knowledge of materials, preferably experienced in production, and with skill in commercial matters. These characteristics may profitably be combined with a special aptitude for purchasing and a pleasing personality. In order to predict business trends and market fluctuations with a fair degree of certainty, he must understand the underlying economic and social forces bringing them about.

Not the least of the qualifications of the purchasing representative is his knowledge of sources of supply and vendor concerns. Promises by firms without ability to fulfill them, or without a record of responsibility are hazards to be avoided.

Purchasing Authority and Policies.—Purchasing activity cannot be standardized, nor can any hard-and-fast rules be laid down which will regulate purchasing authority and procedure successfully. More than any other, the purchasing department must merge into and become an intimate part of the plant as a whole, and in turn receive from other executives the benefit of their specialized intelligence and judgment, and wholehearted cooperation. Buying is not a one-man proposition, it is the result of group thought and action. As the purchasing executive does not initiate the company's business, and as the department is purely a service department, its activities must be circumscribed by at least general policies, and its authority controlled.

Limitations on Purchasing Authority.—A purchasing department may not have greater authority than to buy in accordance with requi-

sitions submitted to it. A purchasing agent can, however, question the need, the quantity, the suitability of any article requisitioned, or make suggestions concerning specifications which appear unduly limiting. If a using department places a properly authorized requisition for a particular standard, and insists on it, then the purchasing agent must procure it under the best terms he can. On the other hand, the purchasing agent may be given responsibility for the stores department, control of inventories, and determination of when and how much to purchase. There are some advantages of this latter arrangement which will be discussed under the subject of stores control. Usually, however, the departments are administered separately, with the stores department under the jurisdiction of the production superintendent, but with the purchasing executive possessing more or less responsibility for the quantity of stock carried. Even with limited authority, the buyer will be permitted to vary quantities of commonly used articles which are requisitioned, if desirable to do so in view of freight rates, dealers' discounts or standard lot quantities. Some firms require executive approval of all orders placed which exceed a stipulated sum. This permits the carrying on of routine operations unhindered, but provides a check on important transactions.

Administration of the Purchasing Department.—In the administration of a purchasing department, the executive will endeavor to pay the lowest average price for materials, utilize a minimum amount of capital, obtain the maximum turnover of stocks, keep inventories adjusted to seasonal fluctuations and business activity, maintain uniformity of product, and secure regular deliveries from dependable sources of supply. He will be keenly alert to possibilities for manufacturing progress as disclosed by offerings of new materials, tools, and equipments. These aims necessitate a continual study of plant operation, materials, markets, and business conditions generally. There must be cooperation with the persons drawing up specifications and issuing requisitions. A favorable reputation and friendly relations with reputable vendors and their salesmen are essential. A proper system of paper work and an adequate file of records and data as a basis for purchasing judgment need to be installed. The purchasing agent must have intimate knowledge of his firm's finances. It will stand him in stead to watch sales activities closely and to anticipate the success of sales campaigns, in order to keep the industrial bark on an even keel with respect to inventories. Above all, he must recognize that a keen intelligence is a desirable supplement to any established procedure or routine system of budget allowances, no matter how carefully worked out in advance, for the winds of commerce change quickly in intensity and direction.

Purchasing Information.—The purchasing executive will seek to build up a volume of data and information designed to increase the buying effectiveness of the department. This material takes the form of sources of supply records, quotation files, and catalogs indexed both with regard to firm name and products. Purchase records are usually maintained, covering all major items which show dates of purchases, quantities, prices paid, current market quotations, and names of vendors. Charts with graphs show market trends and prices paid over a period of years, and these are of increased value when accompanied by notations depicting the reasons for the variations which occur. Information files accumulate pertinent and helpful information with respect to each item, and provide a repository other than the buyer's mind for such data. Reference to it before placing an order aids in formulating specifications attractive to vendors, avoiding difficulties previously experienced in obtaining satisfactory deliveries, and in placing orders at opportune times. Some firms keep a card record of the personnel, manufacturing facilities, service, and peculiarities of vendor concerns. Promises may then be checked against ability to perform and a past record of business relationships and accomplishment.

Bureaus, such as Babson's Statistical Organization and the Harvard Business Bureau, analyze price and market trends of important commodities, provide current facts about general business conditions, and forecast trade activities in various lines. This is readily supplemented with surveys made by many business, credit, and professional magazines, banks and commercial houses. Data of this character will serve as a general guide, but the purchasing executive must correlate them with enough facts about his own business to give him a proper basis for judgment in formulating buying policies for each commodity.

Personal contact with other buyers at local and national meetings provides for the interchange of buying information and is of distinct educational value. *The Purchasing Agent,* periodical of the National Association of Purchasing Agents, is devoted to the interests of those who buy, and is distinctly educational.

Visiting Sellers' Plants.—It is becoming the custom to an increasing extent for buyers to visit the plants of important vendors. In this way first-hand information is gained of products, methods of production and costs; also data as to the size and resources of firms, their equipment, methods, and personnel, all of which is valuable in judging abilities to make delivery and maintain quality. The acquaintanceships and even friendships formed add the personal touch which makes correspondence more effective and expedites shipments.

Knowledge of the material in use is no less important than knowledge of its production, and for this reason representatives of the purchasing department should be in the plant in touch with processes, foremen, and workmen for information. More may be learned in this way in a day of the characteristics and peculiarities of materials, than in the office in a week.

Budget or Schedule Control of Purchasing.—Manufacturing budgets or approved schedules may indicate very definitely what materials are required and when deliveries will need to be made. A graphic purchase schedule for a single item is shown in Figure 136. Sales records offer a check on the program as carried out, and an opportunity to vary the purchasing program to fit the actual situation. In such instances the

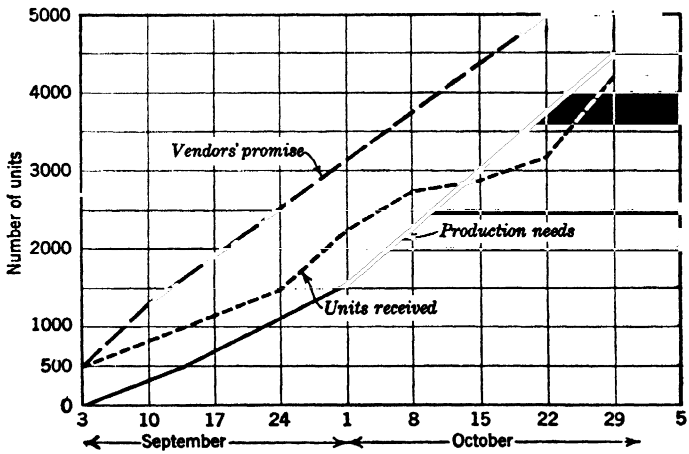


Figure 136. A Graphic Purchasing Schedule

purchasing executive should have authority to provide for needs according to seasonal or budget requirements. One large manufacturer receives his production schedule, covering a half-year period, six months in advance of the date actual manufacturing is to begin. This, when analyzed, supplies complete purchasing information. An automobile accessory company budgets its output on a quarterly basis. An automobile manufacturer watches the material markets and as favorable buying times present themselves, anticipates needs, and places orders accordingly. The plan necessitates executive cooperation with the purchasing department in establishing production quotas. How buying of a commodity may coordinate with favorable market prices is illustrated by Figure 137.

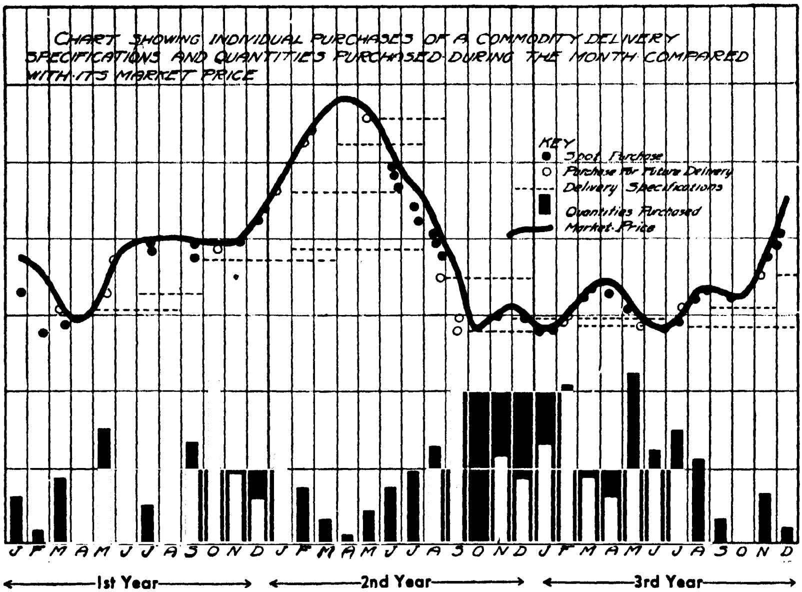


Figure 137. A Purchase Chart

(Prepared by the purchase engineering division of the general purchasing department, Western Electric Co.)

Buying in accordance with budget or schedule needs may preclude to an extent following price trends, but it should mean not higher than average costs. In the estimation of some large companies this is acceptable, and all that can reasonably be expected in any event. Profits are then made on manufacturing and not on buying.

Control of Inventories.—As a guide to purchasing and as a check on inventories it is customary for some stores departments to keep stock cards for each item with maximum and minimum quantities indicated thereon. These are based on normal use and when stock reaches the minimum quantity set, the stores department has authority to initiate a requisition for a predetermined additional quantity. The purchasing department should consider such requisitions day by day in the light of business conditions in order to control inventories within reasonable limits. Inventories have been known to get out-of-hand as much as 100% with serious value losses without this added human control. In times of slow business they may be reduced as much as 50% with consequent savings.

The time interval necessary to replenish the stock controls the reorder point, assuming normal use. In establishing maximum quantities there

must be considered such items as investment, storage requirements, interest and handling charges, deterioration, obsolescence, uniformity of deliveries, dependability of source, and interruption due to transportation difficulties, strikes, etc. Even when thoroughly prepared, however, such formulas serve only as a valuable guide to specific purchasing policies. Variations in business are to be expected, and inventories should fluctuate within reasonable limits according to the particular situation.

Hand-to-Mouth and Speculative Buying.—The practice of buying in small amounts more frequently is justified when prices are high and business is uncertain. It does reduce inventories and lessens storage needs. In many cases the disadvantages are greater than the advantages. Purchasing, selling, delivery, and handling costs are increased and unit prices are higher. Delays in production are more likely to occur. When the buyer believes the market is right for placing future orders, he should have authority to cover requirements, especially when purchasing is dependent upon market conditions and cannot be done profitably on a systematic budget plan. Contracts placed may usually be safeguarded by incorporating clauses which give the buyer the benefit of price declines. Buying in excess of requirements for known production schedules or normal periods verges into speculation and will seldom be authorized.

Some commodities are largely dependent upon weather conditions and are marketed seasonally; others are imported perhaps at irregular intervals. In both cases purchase and storage are necessary, but hedging in the open market should be accomplished when opportunity offers, to prevent loss due to price changes and to assure normal manufacturing profits. The elimination of speculative buying does not mean, however, that market trends should not be studied and followed, because that is exactly what should be done. Buying times should be regulated as far as possible in accordance with general price trends.

Purchasing Capital Items.—The buying of capital items such as machinery, equipment, land, and buildings will normally be handled by major executives, or subject to their immediate control, for decisions with respect to these items usually involve matters of firm policy rather than immediate operation requirements. When authorized to purchase machinery items, the buyer may well look to "those who know" for a decision as to what to buy. The production superintendent and works engineer will probably interview sales engineers and inspect other installations, supplementing their own knowledge and experience. The actual ordering is done by the purchasing department, but the information contained on the purchase requisition as to vendor, style of product, and model number is adhered to strictly.

Technical Aids to Purchasing.—However much the purchasing executive may accomplish, there seem to be three things which he cannot hope to do if he is to have sufficient time for the other phases of his duties. These are: (1) to discuss intelligently the highly specialized and technical lines; (2) to conduct and follow in detail, tests of materials; (3) to know the details of the service rendered by materials and machines, and their comparative values. The careful buyer will utilize the services of the inspection engineer, metallurgist or chemist, or other department heads, as they can contribute to his competency. If not available within his concern, he can make use of commercial research and testing laboratories. Cooperation of this kind usually shapes itself into buying specifications, or in reports of material tests.

Purchasing by Specification.—Specifications aid in obtaining the right combination of qualities or properties in materials desired, and are valuable in bringing about a reduction in variety of items purchased, reducing inventories, interpreting requirements definitely and alike to all vendors, facilitating deliveries, simplifying operation, increasing technical knowledge of materials, decreasing costs and assuring uniformity of quality.

Without an analysis of requirements leading to the formulation of specifications, there tend to be purchased a large number of items of the same general character differing in nonessential characteristics.

Larger orders of fewer items tend to standardize production for vendors, and this is reflected in lowered prices and more prompt shipments; standard articles are more available than special products and will likely be carried in stock. Specifications make quotations comparative and protect the purchaser from misrepresentation by the possibility of applying accepted standard tests. The greater uniformity of materials resulting from specifications enables the designer to utilize them more effectively and assures dealer and customer satisfaction. Formerly the claim of unusual quality was supported by the statement that "we pay high prices for the best materials." Specifications enable the user to secure the material most suitable, and it frequently is the case that lower grades at less cost are equally adapted to the need. Quality and price are important only as they determine relative efficiency.

Portland cement and structural steel offer good examples of the benefits which accrue when widely used articles are manufactured in accordance with standard specifications. They permit uniform engineering design and building construction, and assure standard, dependable results to be foretold by simple and well-known tests and practices. These products also emphasize that standard specification materials are usually made

in large quantities at low unit costs, are offered by more producers, and enjoy a wider market range than special ones.

To the fullest extent possible the purchasing executive should become expert in his field. Specifications prepared by specialists should be edited by purchasing executives to fit them to commercial practice and marketing customs, and this can be done without lessening the value of the materials in use. Specifications needlessly technical and unnecessarily discriminating add to cost. They may very logically be reviewed by selling firms, who will frequently suggest changes which lower production costs, or permit the supplying of commercial grades in lieu of special. A single specification oftentimes gives buying control of a large variety of shapes and sizes of a product, as in steel shapes, thus decreasing the burden and the expense of their preparation.

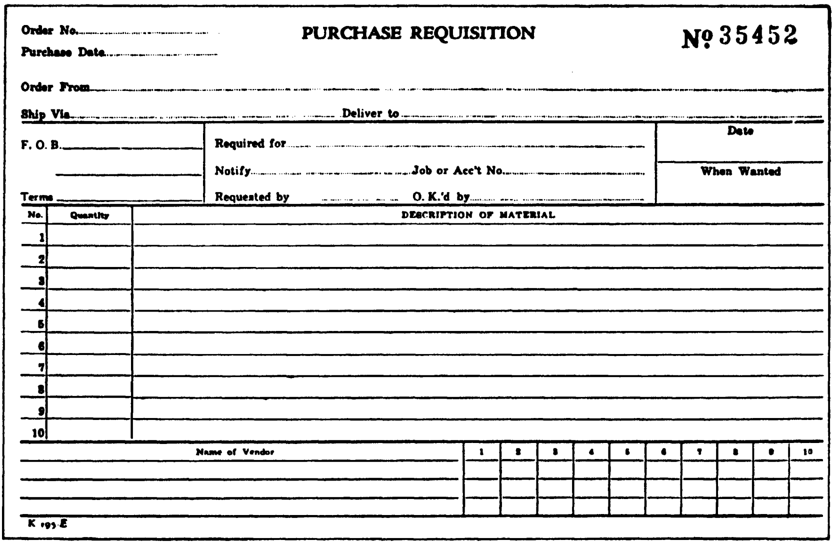
In buying well-known commercial grades and sizes of commodities, specifications may be unnecessary. Helpful, too, in eliminating the need of specifications, is the practice of trade associations in setting up quality standards which are adhered to by its members.

Specifications have largely eliminated personal salesmanship in the buying of raw materials and the sales value of trade mark "autographs" on many manufactured items, except with the "unknowing" ones. This is not so true of articles of equipment or of machinery. The performance type of specification is meeting with favor. Performance, or value in use of manufacturing facilities or tools, is not necessarily measurable by standards of design, properties of materials used, or methods of manufacture; rather, uniqueness in any one or more of these particulars provides the value-giving characteristics. Output, operating costs, overhead, and flexibility in use are the cost-determining elements, and are not readily covered by specifications. Performance is invariably the test of value. Where possible this should be the requirement specified rather than quality, characteristics of materials, or manner of manufacture.

Organization of the Purchasing Department.—The organization of a purchasing department will depend upon the nature of the business and its size. A single executive with one assistant for clerk and stenographer will suffice in some instances; in others the department may necessitate a personnel of a score or more variously trained and qualified individuals. The functions to be performed are the same whether the department is small or large, varying only in extent and importance, and in the expertness with which they are administered.

The Purchase Requisition.—Since the purchasing department is strictly a functional department performing services for others in procuring materials, equipment, and supplies, it does not originate orders on

its own account unless they are of a routine nature. Information on the need for material, including type, quantity, and the time it is desired, is furnished by the department concerned. All this is set forth on the purchase requisition, an important document in purchasing procedure. (See Figure 138.) As its name implies this is a request for the purchasing department to take action, but since it is an internal form no real commitment has yet taken place. It is scrutinized by the purchasing depart-


Order No.
Purchase Date
PURCHASE REQUISITION
№ 35452
Order From
Ship Via
Deliver to
F. O. B.
Required for
Date
Notify
Job or Acc't No.
When Wanted
Terms
Requested by
O. K.'d by

No.	Quantity	Description of Material
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Name of Vendor	1	2	3	4	5	6	7	8	9	10

K 193-E

Figure 138. A Purchase Requisition

ment to see that sufficient information is given and that the request has been authorized by the proper persons. If everything is found in order, and the purchasing department sees no reason to make any changes, it is then prepared to do the following things: (1) ask for quotations, (2) place an order, (3) follow up and secure deliveries, and (4) check and approve the vendor's invoice after the goods are received and inspected.

The Purchase Order.—The purchase order constitutes an agreement to purchase; hence it should be carefully drawn and approved by an attorney. It should designate the quantity of materials wanted, specify definitely requirements, delivery dates, price and discount terms, purchase order number, and provide any additional information for stipulations important to the purchaser. Figure 139 shows a purchase order form which is carefully drawn in this respect. Some firms make the completion of the purchase contract dependent upon the prompt acknowledg-

ORIGINAL PURCHASE ORDER

R. G. LeTOURNEAU INC.

PEORIA, ILLINOIS

E. P. KASTIEN
Director of Purchases

P 45367

Show order number on all correspondence, invoices, shipping papers and tags or packages

Date

Ship to

Ship via

Date Wanted | Terms | F O B

Please Enter Our Order for the Following Material Subject to the Conditions and Instructions Contained on This Form

QUANTITY	DESCRIPTION	PRICE

SPECIAL NOTICE TO SELLER

Conditions
1. DELIVERY. The right is reserved to cancel all or any part if not shipped as requested or promised.
2. PACKING CHARGES. No charge will be allowed for packing, crating or drayage unless specified in quotation.
3. PRICES AND DRAFTS. If prices are not stated on this order, material must not be billed at higher prices than last paid or quoted without notice to us and our acceptance; no drafts for purchases made will be honored unless by agreement.
4. CONDITIONS. If these conditions are not acceptable, inform us before making shipment.

Instructions
1. ACCEPTANCE. **ACKNOWLEDGE ORDER PROMPTLY AND INDICATE WHEN SHIPMENT WILL BE MADE**
2. BILLING. Invoice in duplicate and mail with shipping papers on date of shipment; issue separate invoice for each shipment or carload applying on this order.
3. CASH DISCOUNTS. Show terms of payment and cash discount on all invoices.
4. PACKING LISTS. Delivery tickets or packing lists must accompany all deliveries.
5. AUTHORITY. No responsibility will be assumed for verbal orders given by employees outside of our Purchasing Department.

R. G. LeTOURNEAU, Inc.

By ____________________

Figure 139. A Purchase Order

RECEIVING REPORT

R. G. LeTOURNEAU INC.

P 45367

To be used only for the initial delivery on this order. Use form F 537 E for reporting any material back ordered upon its delivery.

QUANTITY		DESCRIPTION, WEIGHT, ETC.	
Received	Ordered		

Ordered by ____________________ Requisition No.

To be used for ____________________

Received Via ____________________ Car No. ____________ Initials ____________

NUMBER OF PACKAGES RECEIVED

BOXES	BARRELS	CARTONS	CRATES	COILS	BUNDLES

R. R. Express or Cartage Co. ____________________ Pro No. ____________ Frt. Reg. No. ____________

TRANSPORTATION CHARGES				
FREIGHT	CARTAGE	EXPRESS	PARCEL POST	POSTAGE
$	$	$	$	$

Received and Checked ____________ 19___ By ____________

Where sent or del'd ____________________

Figure 140. Report of Material Received

ment of receipt of the purchase order and enclose a postal card or form for this purpose. Return of this form also supplies a promised date for delivery and the proposed routing of this shipment.

Figure 140 shows the report of material received which is sent to the purchasing department by the receiving clerk when the goods arrive at the plant. This is compared with the copy of the purchase order retained in the department files to make sure the two agree in amount and type of goods.

Receiving Salesmen.—Salesmen may reasonably be expected to know their products thoroughly. Usually they are prepared to be specific as to the use the prospective customer can make of their products and the benefits which will accrue. If received without undue delay and treated courteously, they are naturally glad to be of assistance to a buyer. If desirable, arrangements may readily be made for contact of vendor's representatives with production, technical or other executives. This practice aids key men in a plant to keep abreast of new ideas, materials, etc.

Influence of Price in Placing Orders.—Price is but one element in buying, and this fact should be recognized. The salesman must offer superior quality or more attractive prices, and when he approaches a satisfied user of a competing product, a low price is often likely to be his inducement to purchase. A price buyer demoralizes quality by starting a vicious circle of quality shading in order to offer a price advantage. The careful buyer will appreciate quality and service in relation to price and not be attracted, by price alone, to a new and perhaps not dependable source. Price avails little if deliveries are not up to standard or sample, or according to schedule. Manufacturing operations may be disrupted at a serious cost. Thus the dependable vendor may save the purchaser a price differential many times over.

The reasons for low price quotations will be studied carefully. Bad selling and unfair competition are detrimental to all concerned.

"One of the greatest problems of the purchasing agent today is bad selling, particularly selling by those willing to sacrifice profit and, at times, even sell below cost in order to get the business away from a competitor, with the hope that they will be able, later, to retain the business at higher prices. This practice is often detrimental to the industry and places upon the purchaser a burden which he should not have to carry. We are continually on the lookout for unfair competition and, to the best of our ability endeavor to avoid it." [3]

[3] "Purchasing Policies of the Western Electric Company," by J. W. Bancker, Vice President. From a paper delivered before a group of engineering teachers at the Hawthorne Works of the Western Electric Company, Chicago.

Legality of Contracts.—There should be no uncertainty in the minds of either the buyer or seller as to the terms of a contract in all particulars. It should be consummated in legal form and be binding upon both parties. However, the legality of a contract is usually relatively unimportant. Reliance for satisfactory fulfillment is not to be placed in mere legality of agreement, but in reputable firms whose actions are governed by ethical considerations. Penalties or damages exacted from irresponsible sellers by process of law will not satisfy disgruntled customers, nor in most cases will they even reimburse a firm for the added expense occasioned by placing orders elsewhere. To take advantage of a seller by legal means or otherwise is a mistake; shrewdness and sharp practice in buying are obsolete and unprofitable. Mutual advantages and friendly cooperation gain speedy action, assure satisfactory dealing and future friendliness, and should be at the basis of all commercial dealing.

Reciprocity in Purchasing.—It has frequently been customary in the past, particularly in certain lines, to favor the product of one company over others because that company happens to be an influential customer. This is referred to as reciprocity in purchasing because each company helps the other in a complimentary manner. Where no more than a friendly relationship exists and both buying and selling are done on a strictly business basis no harm is done by this practice.

On the other hand, to require the purchasing department to place an order on any other basis than price, quality, and service is to hinder its efforts to effect low costs. Unfortunately this has often been the case when reciprocity is demanded. Profits are diminished and sales advantages largely discounted when a premium must be paid for goods purchased. Competing firms, once suspecting that particular firms are favored, often refrain from making attractive offers and even from quoting prices. This is demoralizing to good buying. Happily the practice of unduly favoring vendors who are customers is being largely discontinued. The policy followed by most purchasing departments is that while judgment and tact must be used in the matter, such firms are entitled to business only on an equal basis.

CHAPTER 29

QUALITY CONTROL

Significance of Quality.—Ultimately, the type and degree of quality, the standards set up to maintain it, the technique of inspection, and finally, the manufacturing process itself are functions of the use to which the product will be put. In a great many instances the user of the product will be the public, in others the user will be another manufacturer. In either case the purpose to which the user will put the product is the final arbiter of quality. Before any inspection is possible it is, thus, necessary to know as exactly as possible the use for the product. Most manufacturing organizations place upon the sales department the responsibility for obtaining this information and making it available to the design, production and inspection departments. The use to which an article is put is constantly changing, and only the corps of salesmen who are actually upon the scene of use can keep pace with this change. The suggestions and recommendations of the consumer go a long way toward establishing the degree and type of quality maintained. It is true, of course, that this is not a one-way affair. The manufacturer looks to the consumer for information concerning uses, but at the same time he suggests different uses and seeks to educate the consumer to a higher quality level. This is a result of competition for markets.

Inspection, Design, and Manufacture.—The inspection of a product to maintain quality is only a part of a complex picture. In order to produce an article which will fulfill the use to which the consumer will put it, it is necessary first to have an accurate design. Unless the article is designed for the use to which it will be put it is obvious that it will not be satisfactory. In addition, however, the design should embody the tolerances requisite to satisfactory use. These tolerances provide the standard of accomplishment which it is the responsibility and function of the manufacturing department to carry out. If the manufacturing department could operate perfectly no inspection would be necessary. The purpose of inspection, however, is not merely the rejection of bad work. The purpose of inspection is to provide the consumer with a satisfactory product, and to this end the inspection department should furnish the manufacturing department with an up-to-date index of its quality level. If this is done on the basis of the most advanced techniques the manufacturing

department will be able to correct deviations before its quality level falls below the design standards. To fulfill its function of controlling quality rather than rejecting bad parts the inspection department must make use of highly scientific equipment and the recent advances in statistical sampling.

Examples of such equipment are electron thickness gauges, contour projectors, electric stress gauges, and the X-ray. The use of statistical analysis in inspection procedure makes possible the determination of the quality level intrinsic in the manufacturing process, thereafter it insures with much greater accuracy than random sampling, that this quality level is maintained. Any deviation from the predetermined level shows up at once, even deviations which are not outside the design tolerances but which indicate the *beginning of trouble.* Statistical inspection provides a

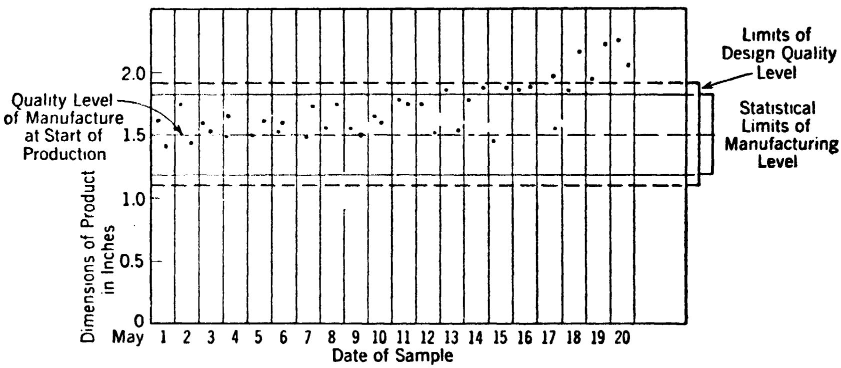


Figure 141. Statistical Variation in Quality

dynamic reading of the manufacturing process and aids in the diagnosis and remedy of defects arising from this process. It is no longer necessary to wait until bad articles have been made to discover that the manufacturing line has developed a fault. Figure 141 shows an example of deviation which was clearly evident before bad articles were produced.

In this figure which may be regarded as representing the analysis of a blanking operation, the quality level intrinsic to the process is determined by measuring a number of samples, averaging and figuring the statistical limits. If these limits fall within the design limits, and the calculations satisfy certain mathematical criteria, production can begin.[1] Additional samples of a number which can be mathematically determined are taken at intervals, here twice a day, measured, averaged, and plotted on the graph. As early as the fifth day it is evident that there is a trend toward

[1] Economic Control of Quality of Manufactured Product, by W. A. Shewhart.

increased size in the blanks. The fourteenth day is indicated by the graph as suitable for checking the blanking set-up, as the tests falling beyond the statistical limits of the manufacturing quality level indicate a loss of manufacturing control. Knowing the engineering of blanking, it is possible to predict from the graph that the die is wearing and producing inaccurate work.

Responsibility of Inspection Department.—The inspection division inspects raw materials, parts in process, assemblies, and finished goods. The raw materials may be such things as pig iron, corn, or felled trees; or they may be the results of intricate manufacturing processes such as magnetos, thread, or lenses. In this work inspection insures that the quality level of manufacturing is not lowered at the start by poor material. Very often this initial inspection is done in laboratories. The inspection of parts and assemblies is usually done along the line of manufacture, either by removing the parts from the line or by routing them through a special inspection division. Inspection of the finished products is often carried out by subjecting them to actual or accelerated use tests. In addition to these duties the inspection division is often responsible for the maintenance of its own standards and all standards in use in the plant. This includes checking all measuring instruments such as micrometers, gauge blocks, color samples. In large plants each department may be responsible for checking its own tools and equipment, while the inspection department checks only the standards used in this process. If the inspection department is to fulfill its part in the whole organization the knowledge it gains must be presented in such form as to improve manufacturing control, suggest better product designs, as well as better designs of machines, tools, and fixtures. Inspection should not end with the statement that a lot is bad, but should provide the means for ascertaining the cause of the defect. Statistical control of quality makes this possible in a majority of cases.

The Functions of Inspection.—Provided with proper designs, materials, and facilities the manufacturing departments might be presumed to function effectively unaided. However, operating executives are likewise responsible for volume of output, meeting schedules, high earnings for workers, and low costs. The immediate pressure of these demands and the fact that consequences for quality variations are more remote and perhaps less tangible make it advisable to have a separate functional set-up for inspection.

Inspection serves to avoid loss of labor on parts or materials which are defective, to check waste consequent upon the use of defective auxiliary equipment and tools, to relieve the foreman of routine duties of this

nature, to safeguard the intent and aim of the designing department, and to provide for the successful assembly of departmental outputs and specialized production. Inspection intelligence supplements the manual work of semi-skilled operators, enabling them to be used successfully on repetitive work. In like manner, by holding work to closer limits than would be the case otherwise, cheaper labor can be used in assembling, and less time is lost "juggling" with parts that will not fit. Inspection also guards against the acceptance of materials of varying quality, and likewise protects customers from receiving products which are defective or of lower grade than intended. Experience shows that manufacturing departments unaided by inspection service do not maintain standards and quality satisfactorily. Inspection is, therefore, the price paid for quality insurance.

Inspection provided to supplement the quality efforts of mechanics and foremen is designed as a helpful, necessary service, not as an antagonistic force of police character. Any other spirit in an organization suggests the failure of management in making clear the common aim of all employed, and in inspiring the operating personnel with the ideals of quality which it seeks to maintain. In small plants, employees who are carefully chosen and personally instructed quickly grasp quality ideals. In larger plants loyalty and enthusiasm toward this aim may be more difficult to engineer.

The Plant and the Inspection Division—Inspectors Subordinate to Supervisors.—There are shops where the workers are concerned mainly with wages, and foremen, under pressure for quantity and low costs, become careless of quality. These conditions may prevail when the grade of workers is low, foremanship not the best, or the production departments lack appreciation of quality aims. Inspection must then guard against incompetency, slighting of work in order to increase earnings or output, efforts to hide mistakes or negligence by passing inferior or defective work, or laxity with respect to equipment or tool maintenance. Under these circumstances more rigid and intelligent control is effected, and a check provided on foremanship by separate administration of the inspection function.

The head of the inspection division should report to an executive far enough up the line who will give due weight to quality requirements, and thereby act as a balance wheel in the production scheme. The engineering department usually has a primary interest in perfection of product, the sales division in consumer acceptance and satisfaction, and the operating divisions in low costs. Under such circumstances it is essential to provide an unbiased authority capable of judging impartially the relative importance of conflicting viewpoints with respect to quality, and recon-

ciling differences between them. This calls for functional control of inspection.

Inspectors as an integral part of operating groups do protect quality successfully in some plants. Favoring conditions are high plant morale, carefully selected workers who are skilled and conscientious, relatively small plants, capable supervisors, and ease and simplicity of inspection. Some small plants report success in depending entirely upon the worker for counting and inspection. Efforts in these directions are designed to reduce indirect costs. The final test of their efficacy is in the results attained. In very large plants where the trend has been to subdivide manufacture by products or kinds of work with a responsible executive in charge of each, he is also responsible for inspection. This arrangement furthers cooperation among subordinates.

Inspectors Reporting to the Superintendent of Manufacturing.—This officer exercises control over all production departments, as well as the engineering or design, and other auxiliary and service departments. His aim is profitable manufacturing into which quality and quantity ideals are merged; his task is to coordinate and balance the activities of all departments to this end. More than any other individual he will possess the proper perspective to permit sound judgments without bias, and the control necessary to effect coordination. Sensitive to consumer appraisal of products on the one hand, and manufacturing costs on the other, he will evaluate accurately the needs of production from a quantity and cost standpoint, as against suggested standards of perfection. His authority enables him to harmonize conflicting viewpoints and to secure adherence to policies and procedures determined upon. When functional control of inspection proves desirable, an organization reporting to and responsible to the superintendent of manufacturing very often proves effective.

Quality Control by the Engineering Department.—This is practicable and sometimes desirable when the product is a technical one, and standards of production high. It is usually assurance of unquestioned quality. However, the arrangement may affect profits adversely. If the designing engineers are primarily interested in engineering perfection, lacking in production experience or familiarity with the product in use, engineering control of inspection may be unnecessarily rigid or theoretical. Technical perfection of product is desirable only in so far as it contributes to worth and usefulness. Engineering theory and professional skill expressed in designs are desirable only as they contribute to manufacturing success.

Engineers may prove unduly conservative in considering departures from tested paths, and to look with unwarranted suspicion upon sug-

gested economies. Experience shows that shop criticism of designs often brings changes which facilitate economical, practical manufacturing, and permits the use of available equipment. Undue refinements, as tolerances more accurate than needed, add appreciably to costs, and from a use standpoint much unwarranted expense is incurred to hold close limits on unimportant parts. Whoever is in charge of inspection should possess both common sense and a "money" sense.

Other Arrangements for Quality Control.—In some instances freedom from manufacturing influence is achieved by having the official in charge of inspection report to the general manager. In large factories this should seldom be necessary, and this officer, busy with general problems of administration, may lack both the time for and insight into the details of this function. Likewise, he is too detached from active operations to effect the necessary coordination which is essential for effectiveness. To encroach upon the responsibilities and duties of the manufacturing executive by such an arrangement is not often justified. When the quality demands are very high, or the duties of this officer pertain principally to plant operation, as in small and subsidiary plants, the arrangements may be feasible.

Qualifications of Inspectors.—The inspector must necessarily be something of a specialist. Ability over a wide range of material or operations is indicative of greater capacity than can ordinarily be utilized economically. H. R. Perry, writing in the *Western Electric News,* says:

> An inspector of raw materials may be a humble hunter of visible flaws, or a skilled investigator, utilizing delicate and complex testing machines; a mere checker of physical dimensions by scale, gauge and micrometer, or, on the other hand, a trained analyst who determines the percentage of adulterant or impurity in materials where they are likely to be found.

Women between the ages of 18 and 25, high school graduates, and production men provide the rough material out of which the great body of inspectors are selected and trained. In the laboratories may be found those qualified by technical training.

Women of the ages suggested learn quickly, while girls fail to assume the necessary responsibility. Women are particularly apt at tasks which call for quickness of perception and deftness of touch, as in inspecting ball bearings, hosiery, knit goods, and many small mechanical parts. In all such tasks where the manual effort is not tiring, nor the work disagreeable or dirty, the work may be segregated and an environment created which appeals to the best type of women seeking factory employment.

Many high-school graduates join the ranks of inspectors after a period of experience and training. What they lack in judgment and experience they make up in willingness and ability to follow instructions. Ignorant of shop practice and production difficulties, they are not unduly sympathetic in that direction, as an ex-production man is inclined to be. Workmen who show aptitude for accurate, painstaking work, and who know "the game," make good inspectors if they are able to assume the new viewpoint which their changed status necessitates. The relative number of applicants from any source who mature into trustworthy, capable inspectors is very small.

For almost all inspection operations standards of judgment are furnished to the inspector in the form of blueprints, gauges, or instructions. From these he may not depart, and they delimit the exercise of his judgment. This method is adopted not with a desire to eliminate the inspector who thinks, but to insure thinking only in terms indicated by the standards provided. This practice provides centralized, intelligent control over what is done, does away with varying individual standards, and obviates the great difficulty of training men to exercise quality judgment.

Competency is not always assured by the ability to interpret and apply correctly the standards provided. The inspector may need to be well informed on the subject before he is capable of grasping the full meaning of the specifications. Where specifications cannot cover all particulars, he should know use requirements in order to judge acceptability. For example, on a machine part surfaces may not be parallel or square; parts not properly hardened or tempered; threads out of alignment; keyways not parallel or not centrally located; holes not drilled or tapped square with the body of the piece; and many details of a like nature. If they are overlooked they are bound to cause vexatious delay on the assembly floor or trouble in the finished product. Likewise, production experience is a great aid in supplementing inadequate and foolish specifications, which are not at all uncommon.

The alert, energetic inspector in the shop comes to know men and machines intimately. With increasing ability he not only recognizes error readily, but appreciates its cause and is competent to offer constructive suggestions for its elimination. He may readily graduate into the ranks of foreman, and this indicates the proficiency which many attain.

Where inspection takes place in the shop and perhaps at the machine or bench of the workman, ability to reject work without provoking the animosity of the worker is a desirable attribute. These "traveling" or "machine" inspectors need to be of a superior type—keen and alert, pleasant of manner, capable of winning cooperation by suggestion, and with skill as mechanics. Friction between the inspector and workers may

lead to departmental differences which seriously interfere with manufacturing profits.

The chief inspector must qualify as an administrator in directing his staff. He needs to have a thorough knowledge of manufacturing and good judgment as to requirements. Familiarity with testing equipments, gauges, and measuring instruments is essential, together with an aptitude for developing needed devices of this kind. An ability to detect fundamental difficulties causing rejections, and to secure constructive action from the proper individuals is a desirable trait. He needs also to exercise patience and tact in carrying on his work and dealing with the various departments whose ideas may be in conflict with each other or his own. Respect for the competency of the inspection staff must exist in the minds of all, and its integrity must be unquestioned.

In addition to these obvious qualifications the chief inspector must have a technical knowledge of the logic of sampling. Except when full, or 100%, inspection is used, the inspector attempts to judge the quality level of a lot from a sample. This is a complex and in many cases a difficult problem. First, it is necessary to see that the parts are tested accurately, and for relevant properties. This is not always easy. For instance, the introduction of an automatic gauge which flashed red lights for undersize, green lights for oversize, and amber lights for correct dimensions revealed in one plant that no parts within the required tolerances were being made, although previous inspection methods had passed most lots. Second, since there are more good pieces than bad in most lots, samples will usually be distinctly better than the lots. The chief inspector must know how to allow for this in inspection procedure, and wherever possible avoid the difficulty by statistical methods.

Centralized and Decentralized Inspection.—Whether to move materials to central inspection departments or bring inspection to the materials, is dependent upon the character of product and the relative economy.

Centralized Inspection.—With central inspection, when an operation is completed on a lot of parts they are moved to the inspection point, inspected, then dispatched to another operation or to stores. This procedure is faulty in not preventing spoilage, in added cost and confusion of handling, and the extra time involved in completing the product. In plants operating on a departmental basis and producing small parts handled in bulk, inspection is often provided at a central inspection station within each department, or at the production control station of each department. At this latter point all goods may be received for the department and finished work dispatched from it, following checking for quantity and inspection for quality.

Inspection at the machine or work station may be limited to the guidance supplied by the supervisor and the worker's own check. The count at completion may then be a check on quantity if the value of the part is small, and the loss slight, even if several succeeding operations are performed on a defective unit. This quantity check may also be important in order to assure the completion of a required number of units, as necessary to complete an order or an assembly. Here, as in all inspection operations, the gain must be weighed against the cost. For the moral effect it may be well to have a check on spoilage and waste at each point where work is done in order to penalize those responsible for it if in excess. In the class of work suggested the machines are usually of a specialized type and the quality of the work is largely a matter of machine adjustment, with less dependence on the operating skill of the worker.

Departmental production may call for operations necessitating skill on the part of the worker or for special machine set-ups, and may be of relative importance from a cost standpoint. Economy suggests prevention of waste under these circumstances rather than risking an undue amount of rejected parts. Inspectors may then check the set-up and the first few parts completed before the operator proceeds with a given lot. When the employee at such a machine has been started correctly on a job and supplied with gauges so that he can make his own tests for accuracy, there is little or no excuse for spoiled or inaccurate work.

Line Inspection.—In mass production effort is made to complete parts in a line of operations of minimum length. Because of the volume or product, and the way in which the manufacturing operations are arranged, it is not feasible to interrupt the movement of parts or product. The time element is also important, and space requirements a factor. For these reasons "traveling" or "machine" inspectors function along the production line as the work proceeds, constantly alert to check errors and imperfections, and to note laxity of maintenance of equipment and tools, the wearing of dies and fixtures, all of which may affect quality. Inspection operations may be incorporated in the manufacturing arrangements in the same way as work operations. In an automobile axle plant this type of inspection provides a check on each unit of product at intervals of 30 minutes during its process.

Strategic Points of Inspection.—For economical inspection, defective products must be rejected at that point in the manufacturing process which will make the net cost a minimum. It is always important to detect faulty castings and inferior material immediately defects are revealed by machining operations, to prevent waste of labor and machine

time in succeeding operations. The same reasoning holds for any mistakes which may occur in the progress of the work. Inspection of all parts is justified before costly operations, or at points where defects resulting from previous operations would be concealed, with a check of a few parts of each lot, perhaps, at other points. The gain must in each case be balanced against the cost in determining when and how much to inspect. For instance, in a certain class of inspection costing 50¢ per hundred parts to insure the material being 95% good, the inspection to insure 98% good might cost $1.25. That is, the gain of 3% in quality may cost an additional 75¢. It is doubtful if the additional inspection would be warranted.

Special Arrangement for Inspection.—Not all inspecting can be performed to advantage in the shop. Materials may need to be moved to special testing machinery or laboratory facilities. Unusual light requirements, lack of quiet, vibration, odors, temperature, humidity, or other adverse environment influences may preclude the use of shop space. The number of inspectors used and space needed may prove a hindrance to production arrangements and suggests a location apart. When women inspectors are utilized in plants employing principally men, the work should be segregated. Moreover, occasions may suggest themselves when impartial inspection will not be forthcoming if workers and inspectors have personal contacts. The cost of transportation and the inconvenience involved in moving materials to inspection areas may be minimized by use of conveyor equipment. Parts may be inspected while en route on such mechanisms from one production operation to another.

Inspection of Tools and Equipment.—Inspection of product is, however, but one phase of the inspection task. It should include a check-up on the condition of machines, cutting tools, and accessory equipment such as dies, jigs, and fixtures, as well as speeds and feeds. A punch press may be out of line or the tool used may be worn. Set-up variations may occur; damaged jigs may affect quality.

Prevention of faulty production is constructive inspection procedure. In many operations the workmen use gauges or other checks as a guide in doing the work, and these equipments need to be looked over periodically. Laxity with respect to manufacturing standards quickly manifests itself in imperfect production. As the inspector is in a position to note these defections quickly he may greatly aid the production foreman. The danger in making suggestions to the foreman is that the inspector tends to assume responsibility for arrangements, and thereby for quality of output. For this reason inspectors are required to offer constructive criticism only in reports to the chief inspector, who will then make

proper suggestions to engineering or production executives concerned. With this policy, the inspector's arbitrary, judicial attitude toward his work is not compromised.

When warranted, a tool inspection division may be created which assumes responsibility not only for the quality of all tools, patterns, and gauges used, but for design as well. With this arrangement the inspection department is definitely responsible for the operating condition of all tools and fixtures as well as for product.

One function of this division is to provide the purchasing and technical departments with information as to comparative merit of different brands of the items used, which is obtained from investigations made and records kept. The opportunity to check and approve designs frequently enables those experienced in the use and purpose of tools and gauges to offer suggestions leading to improvements. If dangerous to use, not sufficiently "foolproof," too expensive for temporary use, or otherwise unsuitable, changes may be suggested. Tools, jigs, and fixtures intended for permanent use may often be designed for almost unlimited wear by providing bushings, adjusting cams, and removable parts.

Minimizing Inspection.—Some kinds of work may call for little inspection. In the making of furniture, for instance, succeeding operations on wood parts may take place with dependence upon the workmen to eliminate defective pieces as they show themselves. Few faulty pieces find their way into assemblies, which are inspected before finishing. In garment making a premium is paid to the worker for imperfections detected in preceding operations. The group premium plan of wage payment is an incentive to accurate work on the part of each member of the group and the checking of preceding operations as progress is made toward completion, if payment is made only for perfect units. Criticism by fellow workers and the time lost in rebuilding faulty units provides incentive for careful effort, and alertness to note the mistakes of fellow workers. Considerable inspection can be dispensed with under these circumstances.

Extent of Inspection.—Experience and the use of statistical analysis has enabled many shops to standardize the extent of inspection of parts, this varying with the specifications for the part and the type or class of machine or worker producing it. This gives a basis for cost and extent of inspection. If occasion seems to warrant, standards may be waived and judgment used to increase the extent of inspection at any time. It is logical to inspect most where the source is questionable. Most attention should be given to the weakest links in the chain, whether these are machines or work stations inside the plant, or outside sources of supply.

Defective parts in limited proportions may not be objectionable on an assembly line or to a purchaser, as nuts or screws. They could be discarded without much inconvenience or loss. If a check showed greater numbers, a workman could be assigned to separate the good from the bad.

One hundred per cent inspection if carefully performed would seem to offer maximum precaution against passing defects. Experience indicates, however, that when complete inspection involves tedious and tiresome work which causes the inspector's interest and physical ability to lag, spot inspection, being less tedious, will be more carefully done. Very often statistical analysis offers better and cheaper inspection than 100% inspection in actual practice.

Inspection of Purchased Units.—A manufacturer may include these as integral parts of his product without detail inspection, depending upon the vendor's inspection department, and perhaps the need for the supplier to protect his own reputation. An example would be electrical equipment for an automobile, a speedometer, a carburetor, or a motor for a washing machine. Some concerns make detail tests to assure themselves of the excellence of the unit in every respect. An alternative would be to study and approve inspection methods and tests used by the vendor.

Where dependence is placed upon a subsidiary or outside manufacturer for a unit whose excellence influences greatly consumer satisfaction, a purchaser may carry inspection into the vendor's plant, and pass all units before shipment.

Checks on Inspection.—In the automobile field it is the practice to check inspection, particularly of new models, by taking a finished unit out of stock and dismantling it completely to ascertain how nearly it complies with requirements.

A knitting company employing women at low wages to inspect the cheaper grades of underwear, supplements a first inspection by a second and final inspection in the pressroom. When inspection operations are repetitive and tedious, as in the handling of small parts, it is customary to reinspect a portion of the work of each inspector to keep all exercising due care and to check proficiency. (See the chapters on wages for incentive plans for inspection.)

Administration of Inspection.—Inspection operations lend themselves to motion and time study in the same way that production operations do, and with the same gains to be expected in lower costs and more effective application of effort. Executive control is possible through the use of standard practice instructions which carefully outline the will of management, as well as the method to be pursued in accomplishment.

The inspector requires guidance over and above drawings or verbal instructions. Drawings are formal instruments and may lack the specifications necessary to make the part perform the duty for which it is intended, leaving the control of these essentials to the knowledge and the more or less trustworthy memory of the inspectors. On the other hand, many parts may vary widely from any specifications that would be tolerated on a drawing by the engineering department, and still serve their purpose perfectly, and if the inspector were to adhere strictly to the limitations imposed by the drawing, he might be compelled to throw out much perfectly good material.

A card file may be developed with a card for each part handled, which will contain notations with respect to that part not to be found upon the drawings, as well as tolerances that would not be permissible on the drawings themselves, but which would often prevent the scrapping of a perfectly serviceable part. Cards may also bear instructions for making tests that may be a trifle out of the ordinary, and, if it seemed desirable to go so far, to specify all of the devices and equipment to be used in making the tests, excepting perhaps the ordinary measuring instruments.

With such a card file one careful "thinking through" of each inspection problem suffices. The desired procedure is made permanent in a record which is immune to labor turnover; and thereby the hazard of questionable memory, and perhaps incompetent and varying individual judgment, is eliminated. The training of new inspectors is facilitated, friction is not engendered between the inspecting and production departments due to varying requirements, and a basis is provided for continued improvement in methods and thoroughness.

The chief inspector will maintain sufficient records, and files of reports submitted by his subordinates. When summarized and analyzed these provide a history of all rejections, and should constantly point toward weaknesses in the production scheme which may be strengthened.

The central inspection office provides a place where the inspection staff may meet for conferences and discussion. Informal interchange of ideas and experiences, and counsel with the chief inspector which will prove both educational and stimulating to morale and opportunity, should be provided for them.

Inspection Devices.—The basis of a great deal of inspection is accuracy of measurement, which is accomplished by different types of gauges, micrometers, and measuring instruments. These in turn must be tested and kept accurate. The Cadillac Company possesses over a dozen sets of Johanssen gauges, accurate to the one-millionth part of an inch,

with which it tests over 25,000 gauges and instruments used by inspectors, valued at more than $250,000. Some concerns gather inspecting equipment at the close of a day's work, check it for accuracy, and have it available for use the following morning. With other concerns inspection equipment is checked each time issued, or at less frequent intervals. Inspection dates of all gauges should be kept on file cards. Punches, dies and jigs may be inspected each time they are checked in.

A reasonable relationship may be established between the type of inspecting equipment used and the intelligence of the inspector. Costly equipment may be made exceedingly simple to operate, perhaps "foolproof." Less costly equipment combined with more brains may be more economical and as satisfactory. In the design of gauges, particularly, the intelligence of the user and his thought habits may be a guide to design. "The micrometer, beam caliper and vernier caliper are too dependent on the personal equation and human sense of the workman to be used by unskilled labor to measure the multitude of parts constantly passing through a large manufacturing department. Solid and adjustable gauges in the shape of plugs, rings and snaps are now universally used, and have been found to be reliable and convenient." [2] In many lines of industry inspection and testing operations have become a necessarily inherent part of the production process, and the equipment required merits the same study as that given to production operations.

Chemical and physical laboratories need to be specially equipped for testing incoming materials, processed parts, and finished product. In many industries, the X-ray is contributing to the effectiveness of inspection by disclosing the interior structure of materials. In the electrical industry much special equipment has been developed, including a liquid gauge, which measures to the one-hundred-thousandth of an inch.

Noise meters register decibels of sound by a pointer on a dial. By optical projection an image of tiny parts enlarged many times may be thrown on a screen. Shapes may be checked, the precision of pitch of machine screws, the perfection of edged tools. Profilometers measure in millionths of an inch the micro-finish of crankshafts and other parts. Photoelectric cells have many uses. Fine color distinctions can be made with them, as the automatic selecting and placing of cigars of varying shades in different boxes, so that any one box will contain only those of identical color appearance. Perfection of finish or brightness of surface may be similarly checked. Infra-red rays detect spots of imperfect chemical compositions in plastic or rubber articles. Machine gauging and testing of parts may become an economical method when the quantity

[2] Educational Bulletin No. 146, Western Electric Company, Works Training Division.

of parts produced is sufficiently large or when the gauging operation involves a tiresome amount of work, or when greater accuracy may be attained. Inspection equipment should repay its cost in two or three years.

Environment plays an important part in many inspecting operations. Ample light of proper quality is often essential. Clean air of even temperature may be necessary. A well-kept room is suggestive of quality, and vice versa. Good vision is likely to be a necessary asset, and if so, an oculist should make periodic tests of the inspectors' eyes.

CHAPTER 30

MATERIALS CONTROL

The Stores Department.—As pointed out in the chapter on purchasing, the procuring of materials and their storage are closely related. In a small company they may both be handled by the same department, but in a larger firm it is usual to have these two functions separated. In this case a stores room or stores department is established whose purpose is to receive, keep, and issue materials and supplies as they are needed in operations. Along with these duties the department must also provide space and facilities for the storage and issuance of finished products and parts manufactured by the company and held prior to sales. A full inventory is frequently divided, and separate storage areas established, according to raw materials, supplies, semi-finished and finished parts, and finished stocks. Many stores departments handle from 10,000 to 25,000 separate items, and some companies will keep well over 100,000 different accounts.

It is obvious that the storage of so much material involves considerable expense and that anything that can be done to reduce the inventory or speed up handling will result in appreciable savings. When a company such as Bethlehem Steel can cut $10,000,000 from its inventory by better stores control this amounts to an annual direct saving of $500,000 in interest charges alone. Additional profits are also made in reduced expenses for spoilage, obsolescence, and handling.

Control of Stores in Mass Production.—One of the essential features of materials control is that the system and clerical work involved do not prove a hampering influence on production. Mass manufacturing industries, such as automobiles, have required and developed a modification of previously accepted stores control methods. This is made necessary because of the tremendous burden they would face if they attempted to store the huge quantities of materials they use and finished stocks they produce. It is made possible by the extent to which they employ standardization and simplification in their products.

Purchasing is done for specific manufacturing programs on an estimate of needs supplied by a materials engineering section. All production is determined by schedules made in advance and contracts are made with the suppliers specifying definite delivery dates. Only enough materials

are shipped in at one time to last the plant for a few days' run. As they arrive they are sent directly to the operating departments where they are needed or sent to decentralized stores rooms where they remain only for a short period. Every effort is made to avoid handling, clerical work, and to keep materials and parts in production. For accounting purposes in many plants it is considered that as soon as the material arrives it is put in process and thus becomes part of the work in process inventory.

Since the finished product is thoroughly standardized it is a simple matter to determine the unit material cost, and from the day's or month's total production the used materials are figured. By adding the total of incoming shipments during the period to the beginning inventory and subtracting the quantities used in outgoing orders, repair stock, and waste, the inventory on hand at the close of the period is easily ascertained. Individual requisitions totaling hundreds of thousands are thus dispensed with, yet complete control is retained. Some mass production companies have to a large extent successfully done away with separate storage departments.

Jobbing and semi-standard manufacturing obviously cannot be handled in this fashion. It is one more of the savings found in mass production. For the big majority of manufacturing companies the storage of materials and finished products is still a major task. The methods used in the control of materials under these conditions constitute the remainder of the chapter.

Duties of the Stores Department.—When the stores room is of sufficient importance to have its own administrative control it will have the following duties to perform:

1. To maintain raw material stores in quantities and qualities to meet manufacturing needs.
2. To keep investment in materials and supplies at a minimum
3. To provide for the checking and inspection of materials purchased, to see that they are in satisfactory condition when received, and in accordance with purchasing specifications.
4. To store all goods and materials properly and safely so as to prevent breakage, deterioration, waste, and theft.
5. To issue stores at times and places, and in the manner designated, as instructed by proper authorities.
6. To maintain a perpetual inventory and stores records which will show disposition and use of all materials issued, values and kinds of goods in stock, and prevent misuse and diversion of materials to improper use.

The perpetual inventory records, or balance of stores sheets, are frequently kept by some branch of the accounting department or the production control department, and are not in the stores room. Entries are then made from reports sent to the inventory clerks by the stores room. Records of this kind are kept more accurately by a clerical force than by stores room employees.

Replenishing Stock.—In a manufacturing business where production is governed by customer orders approximate needs are forecast from experience. Orders received day by day and analyzed by the planning room of the manufacturing department provide a basis for further incidental purchasing to supplement general stocks. Where the product is a staple one and production fairly regular, and in a jobbing business, a system of "maximum" and "minimum" quantities for each item may control reordering. As the "minimum" level is reached a purchase requisition is issued for a predetermined amount, which may be varied in accordance with circumstances and the judgment of the purchasing executive.

The responsibility for control of stores quantities rests with either the purchasing executive or the stores department, except in the case of mass production as previously mentioned. Additions to stocks are usually determined with reference to existing balances. The many items carried under the name of "supplies," and "expense materials," which do not enter directly into the product are very generally handled on a "maximum" and "minimum" basis by the stores department, even though quantities of manufacturing materials are controlled by others.

Procedure Upon Receipt of Purchases.—The receiving section of the stores department is supplied with a copy of the purchase order or notice of purchase as a guide to expected deliveries. Upon receipt, all goods will need to be checked for quantity and quality, and proper reports made to the purchasing department, notification of arrival sent to interested individuals or production departments, and the materials placed in stores or made available for use. To avoid carelessness in checking, the receiving clerk may be required to report items received and their respective quantities. By omitting all amounts from the copy of the purchase order sent to the receiving clerk he is forced to make an actual count of the material instead of merely checking them off.

In many cases a mere count or measure of the material suffices as a check on satisfactory delivery, but in others rigid physical tests by measurement, careful examination of goods, or laboratory tests may be necessary. In the former cases the receiving room employees are enabled to do the work as a part of their regular routine. Where technical intelli-

gence not easily acquired by such employees is essential, the inspection department will need to furnish assistance.

Progressive stores departments make a practice of completing inspections and securing adjustments with the vendor before accepting deliveries and placing materials in storage, even though demurrage is incurred. This procedure facilitates prompt and equitable adjustments by placing the responsibility for immediate action upon the supplying concern. By careful selection of suppliers, however, little difficulty of this nature should be experienced.

Modern Shipping Practices Facilitate Handling of Stores.—Important economies are effected by having materials delivered in standardized ways which save handling costs. A motor company reports that some material is received from outside sources in special racks or containers furnished by the company, or on skids, on which the material remains until delivered to the primary operations. Other examples of special packing are given by W. H. Fleming in the following statement:

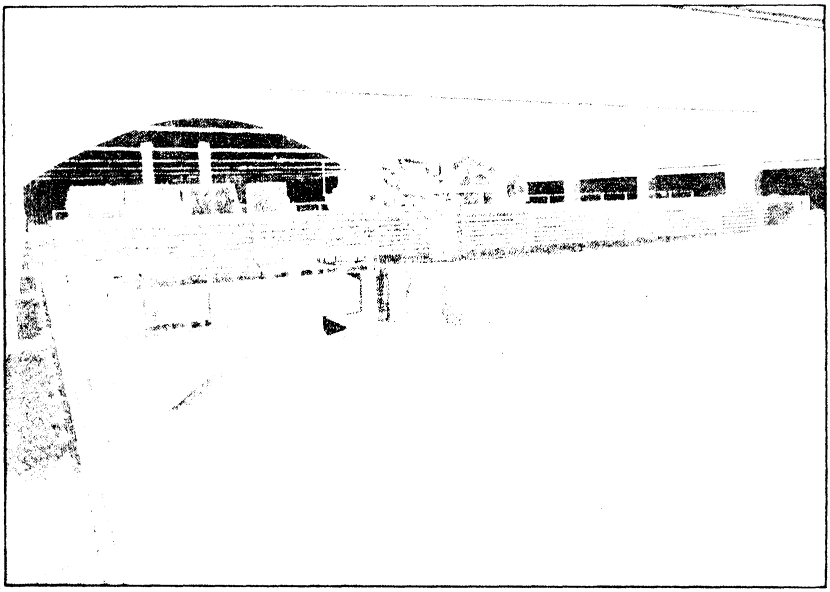
> Carloads of fabric come to the Goodyear Rubber Company packed in a standardized way that has been worked out by our engineers. The heavy rolls of cotton fabric are stacked with an aisle around them, so that a man can enter the car with a flash light and note the numbers stenciled on the ends of the rolls. This method of packing also prevents damage, which might result in claims . . . Rim steel used to cost us more per 100 pounds to unload than anything else in the plant. Now we have it baled in uniform bundles that weigh about 3½ tons and let the crane that used to handle our reclaimed rubber unload and stack it. Such economies have saved us men and money; just in the last year we have reduced our cost of unloading and stacking rim steel from 22 cents to 5 cents a thousand pounds. And we look for further savings while we continue to use this system . . . As far as possible the stock department stores finished materials in unit containers. This eliminates all counting except when the container is originally filled.

Ingenuity in effecting savings by use of improved methods has been essential to manufacturing success during the past few years in many lines.

Storage Methods That Have Proved Economical.—Storage equipment varies widely, depending upon the product to be stored. It may be simply ground area, outdoor bins, covered yards, indoor space, shelving, drawers, bins, racks, hooks, specially constructed fire- or theft-proof rooms, or storage compartments in which atmospheric conditions are subject to control. Examples taken from several lines of industry will indicate progressive practice.

Foundries must care for pig iron, steel scrap, sand, and coke. An overhead traveling crane equipped with a magnet may be used to unload cars of pig iron as received, and make up charges for the cupolas as needed.

Figure 142 shows storage equipment to handle and store foundry sand. The overhead cranes operating clamshell buckets unload sand from cars



(Courtesy of Shepard Niles Crane & Hoist Corp.)

Figure 142. View of Storage Bins and Eight-Ton Grab Bucket Crane in a Cement Plant

at the extreme left into the bins, and as needed serve the hoppers at the right which open into the foundry. Labor cost is reduced to a minimum. Sand needs to be protected from the weather. In the northern part of the country covered foundry material storage yards pay dividends on their cost in protecting materials from snow, rain, and subsequent freezing. When so exposed they are difficult and expensive to handle, and some of them deteriorate in value.

Steel fabricating plants and companies maintaining steel stocks require considerable areas of storage space which are served by overhead cranes. These should preferably be covered, as exposure of steel stocks to the weather causes deterioration and adds to expense of cleaning and painting finished products, but many companies make no attempt to cover rough

stocks of heavy steel bars and shapes. Sufficient storage area is necessary to pile different shapes and sizes separately.

In *furniture manufacturing,* lumber is used by many firms in quantities of from 20,000 to 40,000 board-feet or more per day. A middle-western company receives its lumber in box cars and unloads it onto "bunks," which consist of platforms mounted on trucks which are moved over wide-gauge industrial tracks. Each vertical layer of lumber on the "bunk" car is separated from the succeeding layer by strips of the same thickness as the lumber, placed crosswise. Piled in this fashion with three or four thousand feet to each "bunk" car, it is run onto storage tracks, thence in succession to dry-kilns, storage shed, and finally to the first manufacturing operation, all without the necessity for rehandling. One or two men move the cars readily, utilizing hydraulic lifts for movements in a vertical direction. Following treatment in the dry-kilns, atmospheric conditions in the storage sheds and throughout the factory must be controlled and kept the same. Upholstery materials are received in rolls and delivered to shelf space in stores rooms maintained for this material adjacent to upholstery departments. Their high value suggests the need for safekeeping. Steel wire used for springs is received in box cars and unloaded by gravity into basement storage.

A *cotton yarn and hosiery mill* utilizes baled cotton in spinning cotton yarn and later in knitting hosiery. Received in box cars, the cotton is trucked to an elevator with a large platform area which moves it into storage space in a multi-story reinforced concrete building with 7-foot story heights. The bales are placed on end, sufficient space remaining above for ventilation. Because of the speculative market, space for several months' supply is provided. The manufacturing layout is arranged so that the first operation is near the first floor opening of the elevator shaft which leads to the storage space above. Hand trucks are used as moving equipment.

In a *medicine plant* with an output of 30,000 bottles per day, the bottling department occupies but a relatively small area of the factory floor space. Storage is provided for a two years' supply of senna, a bulky, light-weight leaf product from the African Sudan, for several months' requirements of cane sugar, for bottles, paper boxes, cartons, printed matter, etc. Excepting the senna, practically all materials are stored on lift-truck platforms, enabling truckers to move loads of from one to two tons. Unloading from cars is accomplished by these trucks, although gravity conveyors are utilized to carry bottles directly into basement areas. Power conveyors later elevate them to the bottling department on the third floor as needed. Manufacturing starts on the top floor with the compounding of the remedy, which is piped to immense glass-lined tanks

on the floor below where it is stored and permitted to age. The next lower floor houses the bottling department. Gravity roller conveyors handle packed cartons from the bottling room to stockrooms below, where they are piled on truck platforms awaiting shipment. Favorable atmospheric conditions are maintained throughout the plant to protect the quality of the product.

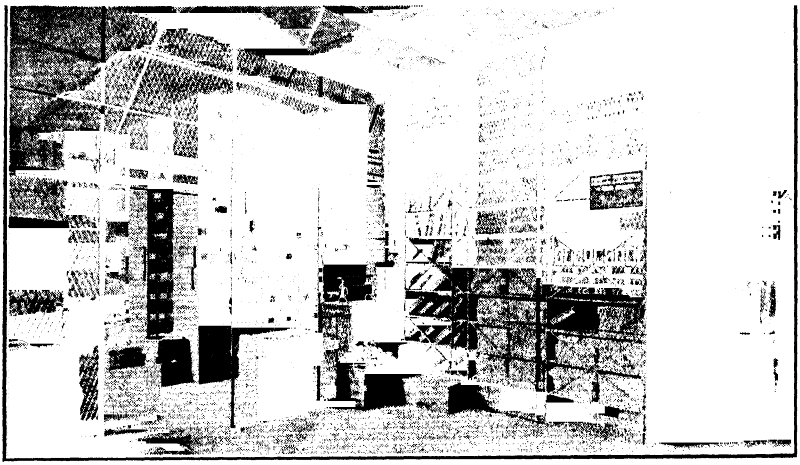
Newspapers, to protect themselves from paper shortage due to strikes or traffic interruptions, need to provide ample storage space for newsprint. One large newspaper receives its supply by truck deliveries. The rolls, weighing around 1,200 pounds, are rolled off the back of a truck onto a tilting device which delivers them into a chute leading to the basement. They pass over a scale where the weight is noted, and are then rolled onto a tiering machine which conveys them into storage. The arrangements are such that one man may handle incoming deliveries and deliver the rolls to the presses as required. Chicago newspapers receive newsprint by boats which come directly from northern paper mills. In other instances cars are switched underneath the plant, and the rolls hoisted vertically to storage. The humidity and temperature of the air are controlled by ventilating equipment, and the air supply is circulated through the paper storage and press rooms. For successful and economical printing, the ink supply must also be "right," and to this end pumps keep it constantly in circulation in the tanks at proper temperatures.

Manufacturers of plumbing, gas and water supply products, and producers of telephones and telephone equipment handle large quantities of small parts, many of which do not require particular protection or care in handling. These, in standard lots, are placed in pans or tote boxes and moved from storage into production, where the necessary operations are performed upon them. Still in the same containers they go as finished parts to assembly lines. Shelving or rack space is designed to accommodate the equipment used, and rehandling of the parts is avoided. When no stock is on hand the shelving space is available for other use.

Drawers are used to some extent for housing *small parts* when the variety of parts is great, the number of each part small, and the weight not too heavy. They afford excellent protection, but the equipment is expensive, and the task of storing and issuing somewhat arduous. They have the disadvantage of encouraging the accumulation of dead stock at the bottom. Deterioration is likely to occur through rust or other causes, particularly when rubber goods or highly finished parts are thus stored. Obsolescence may also result from the accumulation of old stock as changes in design are effected.

Bins for storage are common and are used for holding small parts which are issued a few at a time. As in the case of drawers, there is a

tendency to the accumulation of rejected, old, and obsolete stock in the bottom of the bins. The double bin system eliminates these objections. With this plan two bins are provided for each kind of material. Issues are made from one bin and as the stock runs low and a further supply is received it is placed in the second bin. No material is issued from this bin, however, until the first bin is emptied. Notwithstanding the additional space required, the system is in fairly common use. Figure 143 shows a stock and receiving room in the Federal Sugar Refining Company, where both bins and shelving are used.



(Courtesy of the Berger Mfg. Co.)

Figure 143. Stock Room of the Federal Sugar Refining Company

When *liquids* need to be stored, suitable tanks, barrels or other containers are provided. The delivery of liquids at a distance from the supply is often accomplished by means of pipe lines using pumps or gravity, thus reducing hazards, and conserving nearby space needed for other uses. There are, however, standard racks, especially designed for holding barrels, which conserve floor space and place the containers in convenient position to drain.

Special arrangements will need to be made for fragile goods or those which are inflammable. Chemicals need to be in rooms which are neither too hot nor too cold and which have the proper humidity.

The space occupied by cans causes companies manufacturing them to maintain stocks of sheet tin in sufficient quantity to handle fluctuating demands. Some companies carry stocks varying in value up to one million dollars. As *tin stock* corrodes easily when exposed to moisture a constant

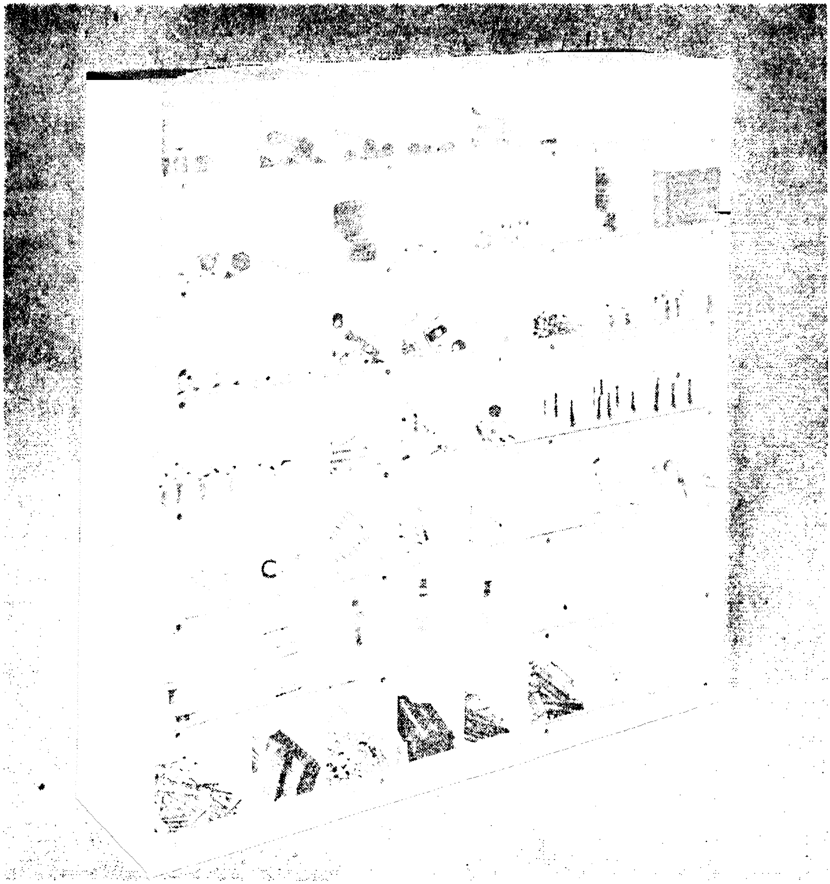


Figure 144. A Section of Steel Storage Bins

temperature must be maintained sufficiently high to prevent condensation. This is frequently provided by automatic gas-fired humidifiers.

Wood or Steel for Shelving.—Pressed steel as a material for building stores room shelving, bins, skeleton frames, racks, drawers, cupboards, and compartments is in almost universal use. It is scientifically designed and constructed to carry any desired load. Developed on the unit principle, it is put up in sections quickly without special tools, enabling the storekeeper to change his arrangement at will without loss of any parts. Adjustments are possible every three inches vertically as well as horizontally, so that the bins can be adjusted to the quantity of stock instead of adjusting the stock to the bins as is often done in wood

equipment. Installations are elastic, and may be moved and re-erected elsewhere. Parts are adjustable and interchangeable. They offer a permanent investment with little depreciation. While wood has the advantage of cheapness, it is likely to prove a fire hazard, to break down and wear out. Makers of steel equipment claim a saving of from 10% to 30% of storage space by use of steel, and a greatly improved appearance of the stores room.

Location of Stores Areas.—Stores departments should be so located and administered that they contribute to lowest possible costs of manufacture. It is seldom possible to locate and operate them ideally, unless the problem is fully considered when determining departmental layouts. In this connection the preparation of charts showing the flow of materials from stores to operations and from one operation to the next is very helpful. The necessary organization of personnel is an influencing factor; the methods and equipment which can be utilized in handling the materials are important. For these reasons, physical nearness of materials to place of use is not necessarily essential, and at times is not even desirable.

Straight-line movements of material and product suggest the location of raw material stores adjacent to the point where operations begin, and finished stock storage near completion point and adjacent to shipping platform. Factors influencing choice of location are: need of protection from the weather, manner of handling, storage equipment necessary, quantity carried, frequency of use and difficulty of handling, value, fire hazard involved, weight, and space requirements. In small plants producing one or a few products stores locations are as a rule easily and logically arranged; in large plants with diverse products and many departments the problem is complex.

The possibilities of gravity deliveries suggest stores locations on top floors, but the utilization of such space is usually more valuable for manufacturing, and the weight of materials to be stored might necessitate special building construction. Where raw materials are reduced in size and weight, manufacturing may logically progress upward through a building with completion on the top floor, utilizing gravity for delivery into storage areas below, or onto shipping platforms. In the manufacture of puffed wheat and rice, raw materials are elevated to the top floor at the rate needed. They are "shot from guns" into hoppers, from which movable bins on the floor below are filled. These are wheeled to one side into storage reservoirs or directly over chutes which convey the grain to the packing machines on the next floor below. As the cartons are filled, packed in boxes, and sealed for shipment, gravity conveyors are utilized to carry the product to intermediate storage areas or directly to waiting

cars several stories below. Many light-weight products may be handled in a similar manner.

Centralized or Decentralized Locations.—Whether or not stores are centralized or decentralized, unity of control should usually be established. Personnel may then be shifted readily to meet demands made upon one section or another, or for special work of inventories. Likewise, stocks may be shifted in accordance with departmental needs.

A single stores room means fewer employees, less area of floor space used, easier supervision, and more effective control. Decentralized stores may be more convenient for operating departments, lessen transportation, and bring storekeepers in closer touch with those they serve. Certainly, control and responsibility should be centralized and methods and operating practices uniform. In general, this policy brings the same advantages which accrue from specialization of effort in other activities.

A plant manufacturing lines which are dissimilar will likely encounter stores problems which make a central stores room undesirable. Concerns manufacturing stock foods, veterinary remedies, family medicines, tablets, toilet articles, extracts, and those which prepare soaps, spices, baking powder, and similar products for distribution would need departmental storage areas. The diversity in character of materials to be stored calls for totally unlike equipment and care. The taste of some finished products would doubtless be affected by the grouping of raw materials of this character.

In the metal trades industry and many lines combining the use of metal and wood or other parts, worked materials and purchased parts constitute an important element of stores. Many companies produce 10,000 component parts, and some over 100,000, which are combined in a relatively small number of sales items. Problems of intermediate and final storage of parts present themselves. Whether or not a finished product from one department shall be stored near place of completion or subsequent use will depend upon availability of suitable storage areas, manner of transportation, whether received in small quantities or large. how issued, and other considerations. Totally finished parts will logically be centralized near points of final assembly. A tractor manufacturer has arranged his storage of finished parts parallel to the assembly line, with stores needed at each assembly point close at hand.

Arrangement of Stores.—Storage areas and rack, bin, or shelving space may be readily identified and found by a system of numbers and letters which serves the same purpose as street numbers and names. Figure 145 shows a stores room layout and typical method of space

designation. Certain general principles are followed in using letters and numbers for this purpose:

1. Letters and numbers are used alternately.
2. Letters are used for those divisions which are fewest in number.
3. Numbers are used for those divisions which are most numerous.
4. Both numbering and lettering are started from floor or walls, in general, upward and outward in the direction where additions or reduction in space requirements would be made. In this way no confusion results from possible changes of this kind.

The shaded area indicated in Figure 145 would be designated as A 2 C, with a further number depending upon its position in C. If

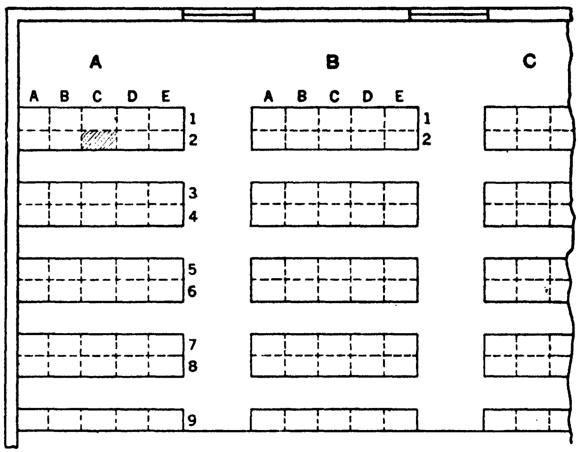


Figure 145. Example of Stores Room Layout and Space Designation

smaller divisions need to be identified, the number of letters and numbers at top and end may be increased. Doubling them would give an index for each one-fourth of the space indicated by the symbol given above.

Classification of Stores.—When a mnemonic classification is used for stores and worked materials they may be placed in the stores room in the alphabetical arrangement called for. No further indexing is necessary, as the location is fixed in the same way that the position of a word in the dictionary is fixed. With the adjustable shelving, bin, and cupboard arrangements possible with modern steel equipment, quite a variety of parts may be housed without difficulty. If the storage equipment required for a succession of articles as they appear in the classification scheme varies too greatly, the scheme will break down because of the

number of exceptions which will need to be made. Variations in weight, bulk, the manner of storage, frequency of use, and difficulty of handling and varying characteristics of the article influence the successful use of the plan. Articles which vary greatly in weight may be classified so as to come next to each other, or heavy articles at the top of bins and light ones near the bottom. Again, textiles or paper may need to be kept separate from articles which give off dust, and from injurious liquids.

Changes in the stock carried or additions necessitate changes in arrangements and equipment and these are not easily made. To anticipate growth may mean a waste of space.

Indexing the stores locations and placing materials and parts in these spaces may prove advantageous. With this method less difficulty is experienced in providing proper storage equipment for each item, in placing frequently used items near at hand, placing heavy parts where handling will be at a minimum, or placing near together those items which are issued at one time for assembly. To find a given item reference to the index is necessary, if locations are not memorized, providing this information is not given on the requisition. Usually stores room attendants will soon come to know the location of nearly all items. When new items are added to the stores no new arrangement of stock is necessary. In large stores rooms the stock may be subdivided among section storekeepers, each of whom becomes thoroughly familiar with his stock. There is then little need for indexing, except to designate the proper section. A growing tendency is to eliminate all possible clerical work and "form" control, in the interest of simplified practice. More reliance is placed on men and less on written orders and mechanized procedures. One firm writes: "It has been our experience that with a reasonable amount of supervision those concerned in storekeeping will generally arrive at the best and quickest way to do things."

Issuing Materials.—All goods coming into stores rooms or withdrawn from them must be accurately accounted for. In most cases withdrawals are by individual requisitions calling for small quantities of a given article. These may be made out by the foreman of an operating department or a clerk in the production control department depending upon the system employed. They are received by a stores clerk who issues the material over the counter or places it at the disposal of truckers for delivery to a designated place. Those issue tickets received via shop mail which call for materials delivered to the operating departments, are accompanied by route tags, which when attached to the stock provide instructions for the move men. With mass production and the elimination of individual requisitions for materials, there is nevertheless the

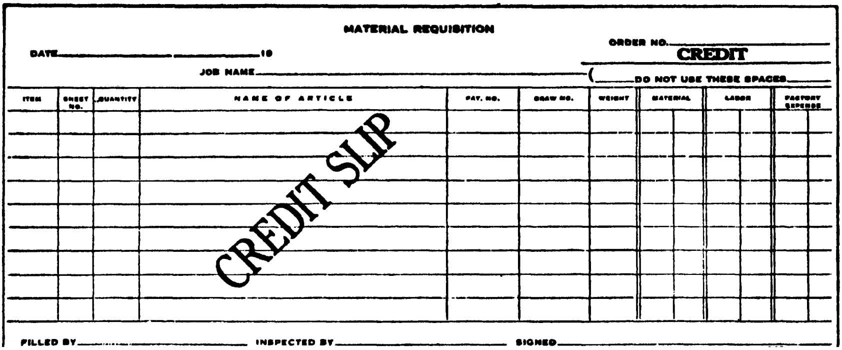


Figure 146. Material Requisition Form

necessity for definite records of receipts and deliveries. These can be summarized in total quantities for a given date on prepared forms which show delivery points and indicate use. Supplies also may be issued to departments in quantities in accordance with estimated requirements, to be reissued to individual workmen as needed. Workmen are under no circumstances allowed within stores enclosures.

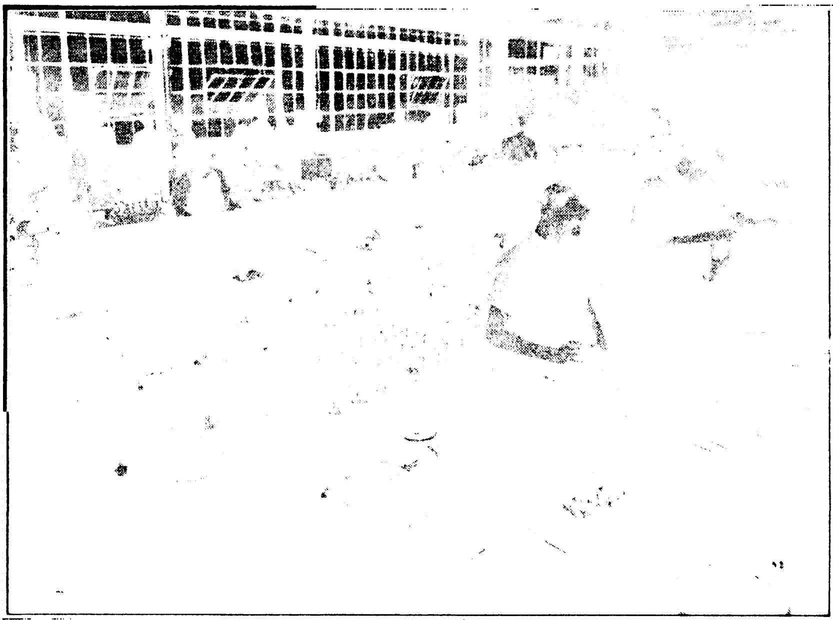
Delivery of Materials.—The Monarch Machine Tool Company, Sidney, Ohio, worked out an ingenious method of delivering parts to men on sub-assembly lines, where a variety of different units must be assembled in small lots.

> The conventional method of solving such a materials handling problem is for the stock room to bring a supply of parts to each assembler and pile them up on his work bench. . . .
>
> Here, however, we solved the problem with specially designed cabinets that serve both as delivery trucks and storage units. These parts-assembly trucks, loaded in the stock room with the detail parts conveniently placed in handy compartments, are wheeled to positions alongside the workmen's benches in the assembly department, and left there.
>
> The parts are only removed as they are needed. In this way, no time is lost in transferring parts from truck to bench, and the parts are conveniently located, kept clean and free from damage or loss.[1] [See Figure 147.]

The Use of Bin Tags.—It is fairly common practice to keep bin tags with each lot of material, and to require clerks to make entries of each replenishment of stock and withdrawal. Experience shows the like-

[1] "Trucks Serve as Storage Cabinets Too," *Factory Management and Maintenance*, Vol. 98, No. 1.

lihood of stores clerks neglecting to make entries, of tags becoming lost or illegible, and of failure of the idea to work successfully. The less clerical work that devolves upon workers not accustomed to it the better. For this reason, when the system employed calls for requisitions for purchases to originate in the stores room, it may be advisable to devise a plan which eliminates such work as a part of the regular routine. To save the time of the storekeeper in writing such requisitions, and to insure that clear and complete information of materials desired was supplied to



(Courtesy of Monarch Machine Tool Co.)

Figure 147. Special Cabinets Serve Both as Delivery Trucks and Storage Units on Sub-assembly Lines

the purchasing department, the Chicago Pump Company instituted the following procedure:

Three bins tags are provided for each item; red, yellow, and buff for raw material; and blue, pink, and buff, for finished part stock. On the yellow tag for each bin are written predetermined maximum and minimum quantities, the part number of the stores item, and under the heading "Description," is written the complete commercial term that is used for ordering the material. As the yellow tag will serve as a purchase requisition, it can readily be seen that the description must always be on it. The

location of the material is a very important feature, too, for checking up on material after the yellow tag has been turned into the office.

A second minimum stock figure, usually about 25 per cent of the minimum on the yellow tag, is recorded on the red tag. This second minimum figure serves as a double check on the purchasing department and a warning to replenish the stores item before it is entirely exhausted. The balance of the data is a copy of the information given on the yellow tag.

The part number and a short description of the stores room item are entered on the buff tag. The minimum and maximum figures can be eliminated.

With all tags on the bin, the yellow tag sent to the purchasing department is a signal to order a supply as indicated. Receipt of the red tag is a warning that the supply on hand is nearing an end, and prompts the purchasing department to "trace" expected delivery of quantity ordered.

The same system is used in the finished parts stores room, but here the blue bin tags become an order on the machine shop to make the maximum number of parts and the "double check," or pink card, notifies the foreman to speed up on the most needed items.

This method is typical of effort designed to reduce the clerical work involved in stores operation, reduce costs, and provide legible, accurate requisitions. It is fitting procedure to the personnel.

The Perpetual Inventory.—The perpetual inventory is the heart of the materials control system in a jobbing or special order manufacturing company. Reference to it will give the amount of stock on hand for any item and other valuable information relating to the control of stores. Under this system a loose-leaf ledger is kept with a sheet for each item. (See Figure 148.) This ledger is kept by the balance of stores clerk in the planning room of the production department. As customer orders come through the engineering department in the form of bills of materials, information is provided in detail of material requirements. The balance of stores clerk by an entry on this form reserves the material necessary in connection with each item, or indicates that it is not carried in stock and is to be purchased. A check on accuracy of entries is secured by balancing quantities available or held in reserve for orders, as indicated by columns 5 and 6, with the balance on hand plus any amount ordered but not yet received as shown by columns 4 and 1.

Balance of stores sheets vary in data recorded. Other forms provide columns for keeping a money valuation of material handled. Practice in the example shown is to keep money values in the accounting department, where several thousand stock items are grouped in 13 classes. In some cases balance of stores records are maintained in the stock rooms, or in the purchasing department. Use of the sheets entails a system of requisi-

BALANCE OF STORES SHEET

MINIMUM STOCK 800 ft	GROUP	NAME OF ITEM 2½" Cold Rolled Steel
QUANTITY TO ORDER 5000 ft	CLASS	SPECIFICATIONS
	MEMBER	

ORDERED (1)			RECEIVED (2)			ISSUED (3)			BALANCE ON HAND (4)			APPLIED ON ORDERS (5)			AVAILABLE (6)		REMARKS
DATE	QUANTITY	PURCH OR STOCK ORDER NO.	DATE	QUANTITY	PRICE	DATE	QUANTITY	ON ORDER NO.	DATE	QUANTITY	PRICE	DATE	QUANTITY	ORDER NO.	DATE	QUANTITY	
									9/16	2000					9/16	2000	
												9/17	200	W3090		1800	
												9/20	80	W3098		1720	
						9/28	100	W3090		1900			100	W3090			
												10/3	400	W4016		1320	
						10/4	80	W3098		1820			—	W3098			
												10/7	600	W4022		720	
10/7	5000	902														5720	
						10/7		W3090		1770			50	W3090			
						10/8	250	W4022		1520			350	W4022			
												10/20	400	R8162		5320	
			10/22	5000						6520							

Figure 148. Balance of Stores Sheet for Controlling Inventories

tions and entries for each addition to or withdrawal from stores. These furnish accounting data and a check on detail use, but in mass production are too burdensome.

Advantages of Perpetual Inventory Records.—The balance of stores sheet insures effective control of stores. It represents the will and intelligence of the executive in action, and suggests what should be achieved if other methods of control are found more applicable. In particular, it (1) regulates stock quantities; (2) controls quantities and time of purchasing; (3) places definite responsibility; (4) reduces theft; (5) eliminates much waste and misuse of materials; (6) prevents accumulation of obsolete material; (7) facilitates substitution of materials; (8) lessens depreciation; (9) facilitates accounting; (10) makes preplanning successful; (11) saves time of workers; and (12) provides a perpetual inventory of stock. The ultimate results are uninterrupted, low-cost production and prevention of many wastes. Quantities of any item may be learned by reference to the records; the total value of inventories may be ascertained by taking a trial balance · and a record is provided of the use of all goods issued.

The minimum quantities stored in each instance are dependent upon the rate of use of the item and the time interval necessary to replenish the supply as detailed more fully in the chapter on purchasing. Production must not be hampered by lack of materials with which to work. A study of each item along the lines indicated will obviously prevent haphazard ordering, largely eliminate excess stocks, and assure continuity of operation. Even for small plants the gains will far outweigh the expense of the procedure and the control exercised wields a definite influence on morale.

Maximum and minimum figures need to be revised and kept in harmony with seasonal demands and business conditions. Each requisition may be submitted to the further test of executive judgment before orders are placed. An executive officer in charge of stores for the Liquid Carbonic Company, says: "It is the ambition of every superintendent and foreman to have enough stock to work with; this ambition unless carefully watched will soon lead to a very high inventory, especially when there are as many minds which have this ambition as there are here." In this plant, with production budgeted, and automatic control of stores quantities provided for within certain limits, final judgment of each requisition is made by an officer in charge. System is not carried too far.

Physical Inventories Needed.—Periodically, an accounting must be made of stores and stocks in order to prepare profit and loss statements.

to check waste or theft, and to adjust book records with the actual situation. Seldom are perpetual inventory records depended upon alone. They are not acceptable to banks or to the government because of the probability of error. Likewise it is poor management that depends solely upon annual or semi-annual physical inventories for information as to the extent and value of its stocks. The loose control and infrequent checks suggested by this procedure tend to encourage waste, misuse, and theft and make operating costs uncertain and high. On the other hand, as a supplement to book records physical inventories are essential.

Methods Employed.—Physical inventories may be taken in several ways: (1) in many plants operations are suspended for the number of days which are necessary, annually or semi-annually; (2) in other cases special crews start checking two or three months previous to the end of the fiscal year, completing their work at that date; (3) other arrangements provide for a more or less continuous check of stocks and balancing with book records.

Suspension of production activities is objectionable for several reasons, not the least of which are the accumulation of overhead cost, the laying-off of many employees, and the loss in production. Nevertheless this is the practice followed in many mass production plants because of their special operating methods. In automobile factories, for example, the period taken for model change-over is utilized to count the inventory at the same time that retooling and new layouts are accomplished.

The foremen, clerks, and labor employed in the work often are inexperienced and unreliable, and because of lack of interest, sacrifice either speed or accuracy. Unless a perpetual inventory has been kept throughout the year the records obtained do not provide a clew to the uses of materials issued. Control is lacking. At any time between the taking of inventories definite knowledge of what is on hand may be obtained only by actual count.

These disadvantages may be overcome in part by the establishment of inventory departments, if justified, which preplan the work in every detail well in advance, and train a staff in actual work of physical counting and procedure to be followed. Then by extensive preparatory work, manufacturing operations are interfered with for a minimum of time.

In the second method suggested above there is less interruption to business, and if the inventory work is done by workers in the respective departments, results will be more reliable. As the count progresses tags are left on each lot of material checked, and additions to or subtractions from the quantity checked are noted on the tag. At the completion of the inventory all tags are taken up, and the figures balanced for that date.

Making Continuous Counts.—With this practice accuracy is assured. In a tractor plant, as material is received, a bin tag is made out and accompanies the material to its proper destination in the stores department. A physical count is then made of the quantity being received, and entered on the new tag. The old tag is removed from the bin and notation is made upon it of the actual quantity remaining in the bin and the quantity received in the new shipment. It is then sent to the stores ledger clerks, where proper entries and adjustments are made. In this fashion a physical count continuously supplements and checks book records.

In some plants the physical inventory is being taken continuously by men whose full time is given to the task. They may work over the stock in an established routine, or minimize the work by counting each day those items which the records indicate are approaching "minimum" quantities. Another company requires that the clerk in the stores room, when issuing material, note on the stores issue slip the amount of the item yet on hand as indicated by the bin tag. The issue slip then goes to the balance of stores clerk, who records the transaction and checks his balance against the figure as given. With any of these plans each item is counted at least once a year and the balance shown in the materials ledger adjusted, if necessary.

Classifications of an Inventory.—A complete inventory will be divided into several classifications, which may be as follows:

1. Plant—buildings and grounds.
2. Machinery and permanent equipment.
3. Production materials—materials of every kind which enter into the final product, including materials in process.
4. Expense materials—all incidental materials and supplies needed in completing the product, but which do not become a part of it; also perishable tools.
5. Semi-finished stock—finished unit parts, unit assemblies.
6. Finished product.

The necessity of taking an inventory of machinery, permanent equipment, and tools, excepting perishable items such as hammers, drills, etc., is obviated by the maintenance of a card index covering such items. As changes occur during the year adjustments are made on these cards. The same applies to plant and building items. If desired, a physical check may be made each second or third year in entirety, or a part of the work done each year. In the case of perishable tools and supplies, when once issued these are usually charged off, although continued in use for a considerable time in some instances.

Inventory Procedure.—The actual taking of the inventory calls for several distinct steps of procedure:

1. A physical check must be made by counting, weighing, or measuring.
2. The material must be identified as a particular stores item, and described accurately.
3. It must be checked for condition, suitability for use intended, possible obsolescence.
4. The preceding steps must be checked.
5. The data gathered must be transcribed on specially prepared sheets.

To facilitate the accomplishment of the first step various counting and weighing machines are available, which are at the same time more accurate and speedy than manual effort. Although hand-counting may result in errors of only 2% or 3%, the cumulative error may be important if the quantity is great. Even very heavy parts may be readily weighed on lift trucks. Accuracy of description and identification is obtained and the work speeded up, if inventory cards with printed descriptions of the materials are attached to each bin in advance.

CHAPTER 31

TOOL CONTROL

Tooling and Tool Control.—A final step in the analysis of manufacturing requirements for the production of an article is the determination of the correct tools needed in performing each operation on every part. Proper tools are indispensable to quality manufacture, influence the amount of work done, and consequently affect costs. Small tool costs amount to many thousands of dollars even for relatively small plants, and for large plants may amount to a million or more annually.

The selection of the precise tool for each operation is an engineering problem which requires considerable analysis. Tooling lies at the foundation of all manufacturing operations, and new products or model changes must frequently be preceded by months of tool planning and procurement. In planning the kinds and quantities of tools needed the final product is broken down into its sub-assemblies and their parts, and all manufacturing processes analyzed.

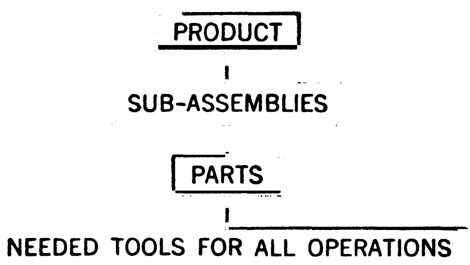


Figure 149. Tool Breakdown Chart

The tooling problem is present not only on the introduction of new products or models but also arises whenever a change in manufacturing procedure occurs. Tool control, on the other hand, is the problem of maintaining the stocks of tools decided upon by the production engineering department and seeing that these are available when and where needed and in good condition for work.

Responsibilities of the Tool Room.—The term "tools" includes jigs, dies, templates, fixtures, and other accessory equipment used to effect

some change in form. As a non-productive department, the tool room cannot show profit, but losses may rapidly accrue from its maladministration. These arise from lost time of workmen, idle machine time, lost tools, theft, damaged tools, insufficient or excessive stocks, and improper maintenance. A tool room that is managed and operated on a productive basis with the same degree of thought and efficiency as other departments can show comparative results. Costs of operation may be checked against allowances for tool cost and tool room service. Upon the tool department rests responsibility for (1) having available proper tools as needed; (2) procedure for issuing and receiving tools; (3) safe and proper storage; (4) repair and maintenance; and (5) tool records and inventories. The problem of tool control differs from that of material control in that tools are usually returned and put in condition for further use, while materials become part of the product.

Methods of Tool Distribution.—In erection or assembly departments it is customary to provide each workman with a set or kit of tools covering his needs; these he retains as long as he is on the particular job. Replacement of worn, damaged, or lost tools is made at the crib, where he will also get any special or extra tools needed, returning the latter as soon as he has finished with them. Nearness of the tool room is of less importance with this method of distribution and the number of men served each day is relatively few.

When standard parts are being produced, and in other cases when operations have been standardized, it is possible to predetermine tool lists and issue proper tools to the workman either at the tool room window or at his machine. Thus one careful planning of tool needs suffices, relieving the worker of this task, and assuring the selection and availability of the best tools for doing the job. In this case time is saved by informing the tool room as operations are posted so that the tools required may be made ready in advance. Delivery of tools, drawings, and instruction cards to work stations minimizes production time losses of both men and machines, and gives the worker opportunity in any idle moments to study the next job.

For active jobs, sets of tools are kept ready for issue, saving time of assembling. When tools are grouped into sets, they may be identified by one "master" job number, and one receipt is sufficient for the entire set. A copy of the tool list should accompany the set, so that it may be checked in correctly when returned. Tools needed by the workman continually, as hammers, wrenches, pliers, brushes, etc., need not be charged out by checks or tags, but on a card which is kept in a file. Renewals of these items are cared for without any paper work by the mere exchange of a

worn tool for a new one. A "replacement" requisition, signed by the foreman, must be presented by the workman seeking to replace a broken tool. Supplies such as chalk, waste, sandpaper, and glue, are issued on the foreman's requisition, which serves as a sufficient record.

In shops doing a jobbing business, in tool-making departments, and when workmen are engaged in miscellaneous repairing operations, tool requirements vary, usually making it advisable for the workman to determine his own immediate needs. These may become known only as the job is analyzed and the available equipment studied. Work of this character calls for high grade workmen who are more competent to choose tools to advantage than the less skilled workers utilized for standard production.

Location of Tool Rooms.—The location and number of tool rooms is determined by: (1) the character of service required, (2) the convenience to the workmen, (3) the cost of administration, and (4) the varying requirements of departments.

A single centralized tool room is more economical to operate than several departmental tool cribs. When it serves assembly or erection operations, or if mass production is carried on, one well-located tool room may supply a large area. This is particularly true when messengers are employed. In smaller plants this is the usual arrangement, but as distances increase and the number of workmen increases, the question of economy will arise.

A central tool room with sub-stations strategically located is the usual plan in large plants. Each sub-crib carries only those tools normally used by the one or more departments it serves, depending upon the main storeroom for special or additional tools. This arrangement is economical, for with the department office adjacent, the workmen may conveniently secure both their job assignments and necessary tools in a minimum of time. The maintenance of separate stocks may increase tool inventories somewhat, but if special, costly, and infrequently used tools are requisitioned from a central source the arrangement may be justified by the added convenience to the workmen. Decentralized stocks can be centrally controlled when pneumatic tubes, overhead carriers or dumbwaiters are utilized to carry control forms or tools.

Tool rooms need to be readily accessible, but they must not hinder the flow of production, or interfere with manufacturing arrangements.

Storage Facilities.—Tool room equipment must be flexible, so as to permit moving or rearrangement which is so frequently necessary. Interchangeable parts and sections are a great advantage. Figure 150 illustrates a well-kept tool crib.

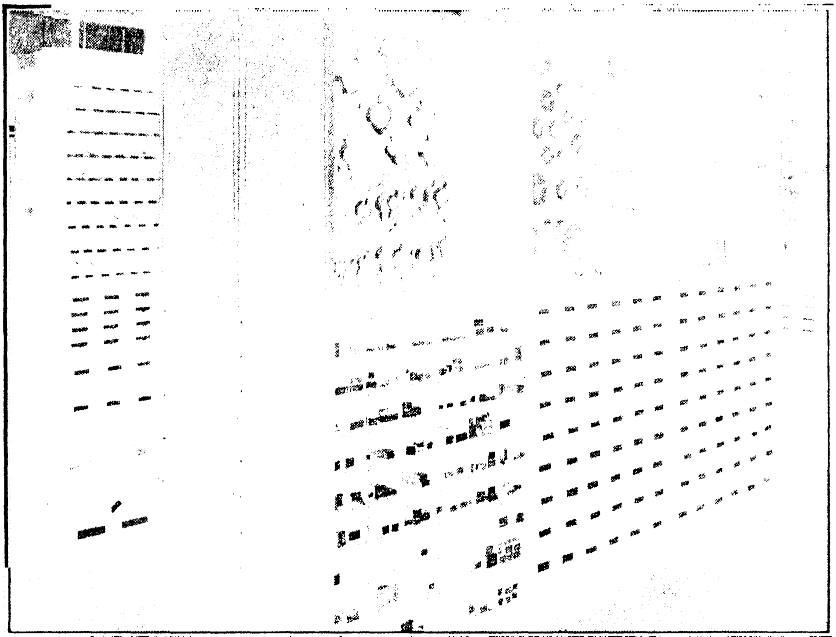


Figure 150. Section of a Well-Kept Tool Room

Pressed steel bins are designed to permit the utmost flexibility in use. Units may be added or fitted into existing installations to care for increasing or changing needs. Office and safe storage sections are readily provided. Individual requirements in the way of bins, drawers, sloping shelves, cupboards, racks, shelf space for heavy or light weight material, may be exactly met, and often combined in one unit. Installations are neat in appearance; the fire hazard is low; maintenance costs are small; and the space occupied is only about 5% of the total space. While wood equipment may be constructed more cheaply, it occupies as high as 20% of the space available, and is also less desirable in other respects.

Accessibility suggests limiting the height of tool storage to about 6 feet. At the beginning ample "fill in" space should be left for the addition of new tools, and space for new sections provided.

Very heavy tools, such as press tools consisting of double-acting dies, templates for blanking tools, and the like, may need to be handled by overhead cranes, trucks, or tractors and may require special storage facilities. Many other tools, such as shovels, picks, ropes and slings, chains, and heavy tools with cutting edges, are kept most conveniently and safely in racks designed especially for them.

Classification of Tools.—For the purpose of identification and inventory it is customary to classify all tools and mark each with a distinguishing symbol. Three general methods of classification are in use: (1) straight numbering, (2) the Dewey decimal system, and (3) the mnemonic lettering system.

TABLE 20. NUMERICAL KEY SHEET—DEWEY DECIMAL SYSTEM *

(Applied to general classes of tools)

1. Sharp-edged tools	All tools that work by cutting off material, except chisels and blanking tools.
2. Measuring devices	All gauges and instruments of precision.
3. Jigs and fixtures	All tools used for duplicating work such as jigs, fixtures, etc.
4. Impact tools	All tools that work by impact including chisels, hammers, etc.
5. Wrenches	All tools that work by causing rotation.
6. Holding tools	Clamps of all kinds, mandrels, nuts, dogs, etc.
7. Fire tools	All tools that are used for melting, heating, welding, etc.
8. Transportation tools	All tools that are used in moving materials.
9. Miscellaneous	All tools not otherwise classified.

* Tool Control, by A. L. Christensen, p. 15.

The straight numbering system is frequently used for small shops because of its simplicity. It supplies inventory information, but the symbol gives no clue to the kind of tool. Consecutive numbers may indicate totally unlike tools. Therefore the tools cannot be stored by number sequence, and when called for the tool room attendant must consult an index in order to identify and locate them.

The Dewey decimal system provides a symbol which, in addition to its value for inventory purposes, serves to describe the tool. With this system the first digit is usually used to indicate the general class to which the tool belongs. (See Table 20.)

Further differentiation may be made in each group to the extent considered essential for ready and positive identification of a tool by its symbol. For example, considering the items of drills and taps, which are sub-groups of sharp-edged tools, this system would show: [1]

1.1	Drills
1.11	Twist drills
1.112	Taper shank twist drills
1.1123	High-speed twist drills with taper shanks
1.11234	High-speed taper shank twist drills of standard length

[1] Tool Control, by A. L. Christensen, p. 15.

1.2	Taps
1.21	U. S. Standard taps
1.212	U. S. Standard taps with machine shanks
1.2123	U. S. Standard high-speed taps with machine shanks

As the cipher "0" is usually not used because of possible confusion with the letter "O," each digit position is limited to nine divisions. This may prove a disadvantage. Another objection is that when the symbols are not in themselves suggestive of the article, and when six or seven numbers are used it becomes difficult to associate the tool with the symbol.

The mnemonic system of nomenclature has the advantage of giving greater flexibility, and at the same time providing symbols which from their connection with the name suggest the tool described. Twenty-two divisions of each digit position are possible with the alphabet, omitting the use of I, O, U and V, because of possible confusion. The tools may be divided into groups according to use, and further divided into sub-groups according to differences. Table 21 gives a general classification.

In subdividing the general group "Measuring Devices," the first consideration is the different kinds of such instruments. These are as indicated in Table 22.

The symbol MG would thus describe a gauge. Gauges are of various kinds, such as caliper, depth, alignment, etc. The symbol MGC logically suggests a caliper gauge. As caliper gauges may be of several types a more accurate description may be required to identify a particular instrument. If it is an "internal" caliper gauge, the symbol MGCN is applicable. Still further differentiation is possible by the addition of more letters. Without confusion, sizes may be indicated by numbers in conjunction with the letters, which is not readily possible with either of the number systems.

Tool Room Control Systems.—Methods of controlling tool issues include: (1) the single check system, (2) the double check system, (3) the triplicate slip system, and (4) variations of the check and slip systems.

The Single Check System.—With this plan each man is given a certain number of brass or aluminum checks bearing his payroll number, which may be exchanged for needed tools. It is frequently desirable to restrict the use of tool checks to the department where the worker is employed, to prevent the misuse of lost checks and to localize tool distribution. When a check is exchanged for a tool the check is hung on a

TABLE 21. KEY SHEET FOR MNEMONIC CLASSIFICATION OF TOOLS *

GENERAL TOOL GROUPS

A.	Abra ding tools	All tools for filing, grinding, scratching, scraping, etc.
B.	Blanking tools	All tools for blanking, bending, drawing, flattening, piercing, shearing, swedging and trimming.
C.	Clamps and holders	Devices of all kinds, including bolts, nuts, screws and washers for holding work.
D.	Drilling and boring tools	All tools that remove metal from interior, including drills, boring bars, cutters, lathe-boring tools, reamers, taps, and holding devices for this class.
F.	Heating and lighting tools	All tools used for melting, molding, tempering, and annealing.
H.	Hammers	All tools that work by striking or being struck.
J.	Jigs, fixtures and templates	All instruments for duplicating work.
M.	Measuring devices	All gauges and instruments of precision.
P.	Paring tools	All tools that remove chips from surfaces (excepting slotting and milling tools).
R.	Revolving cutters	Including milling cutters, gear hobs, circular saws, etc., and holding devices for this class.
S.	Slotting tools, etc	Including hack saw and slotting machine tools.
T.	Transportation tools	All tools used in moving materials.
W.	Wrenches	All hand tools causing rotation, except die holders and tap wrenches.
Z.	Special or miscellaneous tools.	

* Tool Control, by A. L. Christensen, p 21.

TABLE 22. FIRST STAGE OF BREAKDOWN OF MEASURING DEVICES †

M – MEASURING DEVICES

All gauges and instruments of precision

MA	MN – Indicators
B – Bevels	P – Protractors
C – Calipers	Q – Squares
D – Dividers	R – Rules
E – End measuring rods	S – Scale weighing
F – Reference disks	T – Timing device
G – Gauges	U – Plumb bobs
H – Pressure gauges	V – Verniers
J –	W –
K – Electrical	X – Heat measuring
L – Levels	Y – Miscellaneous
M – Metering	Z –

† Tool Classification, by Frank B. Gilbreth.

bin hook, and when the tool is returned in good condition the check is removed and given back to its owner. The system is simple and may suffice in relatively small shops where the attendant is able to supplement such control by personal knowledge. When total dependence is placed on the system it is open to various objections. Checks are knocked off the hooks, placed on wrong hooks or lost. These possibilities enable a dishonest employee to return a cheap tool in lieu of a costly one and claim a check. The extent of the task makes it difficult to check all bin hooks. There is no way of knowing what tools are issued, or the time they are kept out. A workman lacking tool checks may borrow them and secure tools, a practice which causes confusion. Tool checks are frequently lost by being sent to the laundry in overalls, otherwise misplaced, or stolen. Although a nominal charge of $.25 or $.50 for lost checks may be made, there is no certainty that such checks may not have been used to secure expensive tools.

However, hooks can be used from which checks are not readily knocked off. Also certain classes of tools such as jigs, fixtures, punches and dies, special chucking jaws, boring bars, forming tools, machine attachments and appliances are protected from theft by their weight, bulk, or inapplicability to any use except that for which they are primarily intended. These tools are used only on specific work and are not in constant use. The brass check system serves admirably for their control.

The Double Check System.—A certain number of checks are issued to each mechanic as in the previous system. Within the tool room there is hung near each tool a metal disc bearing the same symbol stamped upon it as upon the tool. Adjacent to the issue window a "tool board" is provided with a hook, properly numbered, for each workman. When a brass check is exchanged for a tool the former is hung upon the bin hook from which the tool check is removed. This is hung on the workman's hook at the tool board as the tool is issued. A survey of the tool board gives information of tools which are out and who has them. If all the tools are required to be turned in at quitting time opportunity for dishonesty is largely decreased. However, as ordinarily used, the plan is open to the same abuses as the single check system. Losses, over and above breakage, are estimated to vary between 15 and 25% with the use of the brass check system.

The Triplicate Slip System.—With this system three copies of the tool requisition are made by the workman at one writing, each of a distinctive color. Compactly, in a cabinet or on a wall, there is provided on a series of leaves a spring clip for each tool carried in stock, and one

for each workman. Each clip is suitably marked with the symbol of the tool, or the man's name and payroll number which it represents. When the workman receives a tool the first or white copy of the requisition is placed under the man's clip, and the second, a pink slip, under the tool clip, while the third, a yellow one, is given to the man and serves as his record. When the tool is returned both slips on file are removed and the white slip is given to the workman who destroys it. The white slip only should be considered a charge slip.

If the number of tools which can be drawn is limited, a list of them may be printed on the requisition slips, and those wanted simply checked. If the tool list is large a description of the tool, usually by symbol, will need to be written. To facilitate the issuing of several tools on a single requisition, the slip may be so divided that a description of one tool only is written in each space. The man signs the slip with his name and number. The attendant will then stamp the man's number, the requisition number, and the date on each division, and place it under the proper tool clip.

This system of tool control furnishes a signed receipt by the workman for all tools issued to him. It establishes responsibility for all tools issued, and is "foolproof" in that misplaced slips can be returned to proper places. Dishonest mechanics will find it difficult to "beat" the system. When tools are expensive and of a kind easily appropriated, this system is necessary.

It has certain disadvantages in that the installation is more costly, and it is somewhat more expensive to operate, although not slower. Many workmen make hard work of writing, and attendants may need to assist in making out requisitions. When McCaskey registers are used, the cabinets may be closed and records locked. At the Worthington Pump and Machinery Corporation plant, tool boards with clips occupy a space 25 inches wide and 10 feet long, holding a complete record of 40,000 tool items, or 4,000 items per foot of width.

A Tag System.—This system involves less paper work and the use of less equipment than the triplicate slip system. When an employee draws out a tool, the tool room attendant writes the name or symbol of the tool on one side of a small paper tag, on the other side the man's clock number, below which the man signs his name. The tag is then hung on the employee's hook on the tool board. When the tool is returned, the tag is taken from the board and returned to the workman, who must destroy it. If it is important to know the location of tools in the shop a second tag bearing the worker's clock number can be placed in the tool compartment.

Tool Room Records and Inventories.—The establishment of a tool room or sub-crib presupposes a decision with regard to the variety and extent of the stock to be carried. The data should be prepared in a permanent form.

A separate card may well be kept for each item, giving the tool symbol, quantity, sizes, description, unit and total prices, its location in the tool room, dependable sources of supply, and space for remarks covering service. The record of special tools should specify the items of the product on which they are used. These data provide a ready reference when purchases are being considered, adjustments are made for broken or damaged tools, or values are being placed on tool kits.

Many kinds of tools wear out, or are broken or lost, necessitating replacement. To keep track of such losses and replacements a balance of tools form is used, which is similar in function to the balance of stores sheet used in the stores department. Columns are provided for purchase information, such as the date of order, quantity ordered, delivery date, date received; also for a record of tools charged off. The maximum and minimum number of the unit to keep in stock, and the number to order is given. The first entry on this form would be the quantity on hand and the date of inventory. Subsequent additions by purchases, minus losses as recorded, provide a book balance, which should be checked by frequent physical inventories.

Frequent, unexpected checks on tools in the hands of workmen are desirable. They serve to remind him of the value of the tools which are charged to him, check possession, prevent borrowing of tools from others in order to pass inspection, and suggest the return of those not needed.

When the use of a tool is discontinued for any reason a complete report should be prepared giving the reason, together with any information which will be of value to those responsible for purchasing, design, or the successful use of tools. A study of the tool's history together with suggestions from the operation department for improvements, often leads to worthwhile changes.

Tools are readily classed in two groups—permanent and perishable. Only the former are carried on the inventory records as an asset. The latter group when issued to the tool room are charged off as an expense, although possibly serving a useful life for some time following.

Keeping Inventories Down.—Tool inventories may easily become 10% to 50% larger than what is necessary for efficient production. Tools are bought or made to be used, and when they remain idle while they might be put to use, costs mount. Expensive and infrequently used tools that are needed in more than one department may be placed in a

centrally located crib and obtained from there, rather than keeping duplicate stocks. Production should not be hampered by lack of tools, but the planning department can see to it that certain expensive tools are not scheduled for use in two departments at the same time.

Workmen frequently keep tools at their machines or benches long after the use for them is past. An effective method to get unneeded tools returned is to supply each workman with two large and strong paper bags just before quitting time. On one bag is printed "Tools to be returned to me," and on the other one, "Tools to be turned in." The workman sorts his tools into the two bags as indicated, signs and dates the bags, and leaves them at the crib as he passes out of the plant.

Besides inducing the workmen to turn in the tools they no longer require, this device permits tools in use to be regularly inspected and repairs and replacements made when necessary. It is economical in time used and results in a more fluid inventory. Missing tools are charged to the account of the worker responsible.

Utilizing standard tools and adhering to standard sizes whenever possible will aid greatly in maintaining smaller inventories.

Purchasing versus Making Tools.—For the ordinary plant to purchase tools rather than make them is the accepted general policy. This concentrates such work in the hands of specialists, usually assures considerably lower costs, and leaves the firm free to concentrate its energies upon manufacturing its particular product.

In small plants, tool-making departments are often maintained for the making of those tools and appliances which are special for the plant, particularly those of a temporary character, and for repairing tools. Their chief virtue is prompt service. In large concerns these departments attain considerable importance because of the great amount of tool designing and manufacture made necessary in producing special orders. The use of machinery and equipment special to the plant in the production of monoply lines also suggests the greater need of highly developed tool-making departments on a production basis.

Some companies find it advantageous to purchase machines and adapt them to individual needs. Because of the recognized advantages of specialization, however, the aim is to utilize standard tools and fixtures to the fullest extent possible.

Tools of a permanent kind designed for unlimited use call for the best product of the tool-maker's art, and may be designed with removable and adjustable parts to facilitate repair. These are logically purchased from specialists. Tools of a temporary character, to be used only a few times for a particular order, are most often made within the plant.

With the receipt of a special order, or the acceptance of a new design, a complete list of tools necessary in its production is prepared by the production engineering department. A chart may be made showing those available, which are to be purchased, and which to be made, with columns to show progress in design and purchasing. This will serve as a guide to the planning department in scheduling work. Drawings for tools should be approved by the superintendent of the department where the job is to be done.

The liquidation of tool stocks of suspended or bankrupt firms frequently offers opportunity for acquiring needed tools at less than the cost of making. In purchasing, seasonal price trends in the tool market should not be overlooked.

The production engineering and operating departments should be continually alert to possible savings with new tools or with other brands than those already used. To this end careful records of tool service should be maintained. Progressive plants encourage sellers to demonstrate the worth of products by practical tests. Considerations besides the immediate differences in cost are saving per unit of product, total saving, expense of accessory equipment or special appliances needed, and any difficulties or hazards involved.

Control of Tool Costs.—Tool costs and the plant investment in tools tend to increase abnormally unless carefully controlled.

An analysis of tool needs and of tool service makes accurate preplanning possible and facilitates budgeting of tool expense. In the automobile industry, particularly, this is accomplished. A tool allowance per car is made the same as for labor and production expenses. In one instance the cost of renewals has decreased 71% following the adoption of this plan. Each foreman is checked as to the amount he is running over or under his allotment, and is kept informed of the cost of the tools he uses. As an incentive to the use of reconditioned tools, no charge is made for them, the first department to which they have been issued standing the full cost. For example, a drill worn too short for use in one department, when reconditioned, may be serviceable in another, and the same may be true of cutters, reamers, and grinding wheels. Tools which for one reason or another have been charged off or are infrequently used may be displayed and made accessible to foremen and workers, who may find advantageous use for them in the work they are doing.

Another method of reducing tool costs, which is practicable in some shops, is to encourage the men to own tool kits. Mechanics take pride in the ownership of fine tools, and the management can well afford to handle sales on an instalment basis at net cost. Shops adopting this

policy report more accurate workmanship, less work at the tool crib, lower tool inventories, less theft, and much time saved in obtaining tools.

Worker cooperation is a big factor in controlling tool costs. The efforts of a salvage committee in one plant reduced the number of small perishable tools drawn from the stock about 75%, decreased tool breakage by two-thirds, and caused to be returned to the tool crib nearly $5,000 worth of tools of all kinds which were not in active use.

Obsolescence must be constantly guarded against. Investments in tools increase due to improvements in tools and the introduction of new equipment or methods, with consequent changes in tools used. The discontinued production of certain parts or products "shelves" other tools. Patterns in a foundry illustrate the short life of special tools, used in producing a single product, perhaps a single order. A worthless pattern suggests the lack of value in any special tools used in the machining of the casting. Infrequently used tool equipment is a questionable asset.

In jobbing shops a tool appropriation may properly constitute a part of the job estimate and cause tool expenditures to be checked by the cost department. Failure to charge jobs with proper tool costs increases apparent profits, but inflates tool inventories beyond their real worth.

Tool Room Personnel.—The head of the tool room should possess an understanding of tools that comes from experience in using and making them, combined with the qualities expected in an administrator. These include the ability to direct men and work in harmony with others, to maintain accurate records, and to plan ahead and prepare for production department needs.

Attendants who serve operators need to know stocks thoroughly and the uses made of tools in the shop. If intelligent in these respects they can function with judgment and correctly interpret inexact and vague tool descriptions. Tact, good nature, and honesty are also essential characteristics. These men should become familiar with methods of procedure and control records and policies as a prerequisite of possible promotion to jobs as tool-crib foremen or tool inspectors, or to positions in the tool making department.

Depending somewhat upon the size and scope of the department, there will be added clerical help, men or boys to deliver tools, repair men, and perhaps tool-makers. This latter group may be so numerous as to suggest a foreman in direct charge who plans the work and directs operations. In large plants the tool-making department is under the direction of the production engineering department.

CHAPTER 32

PRODUCTION CONTROL

The Separation of Planning From Performance.—One of the basic ideas of scientific management is that the burden of planning the amount and order of production should not be imposed upon those who are engaged in actual operations. Two distinct types of activity are called for, and they are best performed by different classes of individuals. Operating men are anxious to get their work finished and often do not care to undertake the tedious details that are necessary for effective planning.

Some planning is necessary in all activities. When it is considered that coordinated effort must be maintained between the demand for the company's product, purchasing and storage of supplies, individual manufacturing operations, assembly, and many supplementary activities, the importance of a unified plan can be realized. With the production control or planning department rests the responsibility of weaving all this into a master pattern that will result in maximum, speedy, and economical manufacture. Its authority is usually limited to utilizing the equipment and personnel provided, for it cannot usurp the rights and duties of the other departments in their own spheres.

Coordinating Production with Sales.—The preparation of a company budget entails consideration of and decisions pertaining to the volume of business anticipated and planned for. The factory planning department will endeavor to get results in accordance with company plans. It may frequently be helpful to the sales department in correlating production with sales, and in furnishing accurate information of delivery dates.

Lyon Metal Products, Inc., Aurora, Illinois, manufactures steel shelving, lockers, counters, and fixtures. Formerly customer orders were made up from stock, but a shortage of any one item would hold up an entire order. A change was made to production according to a quarterly schedule list covering all products. Lockers are scheduled in "L" schedules, standard shelving in "S" schedules, and the like. There is actually not less than one schedule per week on each product. Salesmen need only to refer to schedule lists to note the next production schedules for the products the customer wants. Shipping dates are given as well as

starting dates. On the day after each schedule is closed to further orders, factory departments are advised of the total weight of products the schedules call for. This weight factor provides a dependable basis for determining requirements in materials, man-load and use of equipment.

The W. F. Schrafft & Sons Corporation, Boston, manufactures a general line of confectionery. This seasonal business may be charted in accordance with judgment and experience, but a better way was found. An analysis of sales records disclosed that although total annual sales for a given kind of candy varied, the sales for any one month, as January, were about the same per cent of the total for the year. By utilizing a column of averages it is possible to take the actual sales for any given period, say January and February, divide it by the percentage of sales for the two months, and obtain an estimated annual sale. If the amount sold in January and February is 6,000 cartons, it follows then that the estimated sale for the year is 6,000 divided by 20.27%, or 29,600 cartons. Every month we determine a new annual estimate. Notice that by this method we capture the present trend of sale of a particular item, and if the tendency is upward we automatically manufacture more; if the tendency is downward, we manufacture less, and find that we rarely have too much or too little.

Results of Formal Planning.—The introduction of a planning department definitely separates planning from performance. Workmen are left free to do the work as planned and arranged for; foremen to coordinate efficiently and utilize the equipment, materials, and labor in the manner prescribed. Those who plan the work are given greater opportunity to develop the technique of planning by intensive experience, research, and the compilation of data bearing on this phase of the task. Planning calls for different talents than needed by operating men, and with this arrangement specialists may be chosen for it.

It is true that two plants, one with a formally organized planning department and one without, may turn out a given product in the same volume and of the same quality. Obviously work must be planned and performed in both plants. In both instances material must be available for the work, jobs must be assigned to machines, work must be routed, costs estimated, auxiliary departments must function, and production routine be controlled. This emphasizes the fact that the inauguration of a planning department does not introduce any *new kind* of work to be done. Differences are chiefly in the manner in which the work is handled, and the probable gains in effectiveness of the new arrangement. Usually more work is turned out by fewer workers, total costs are decreased, production time shortened, and orders shipped when promised as a result of formal planning. The department is frequently styled

"the brains of the plant," because of its control and direction of operating activities.

Operation Without a Planning Department.—In a plant without an organized planning department, production orders receive the attention of the factory superintendent. Under his direction they are incorporated into a master schedule according to dates shipments are to be made. They are then broken down into manufacturing orders. Subdivisions of the order may be consolidated with parts of orders from other customers in order that lot sizes may be held at profitable manufacturing quantities. Production orders are then issued to the proper department heads, who possibly again subdivide the work among foremen in their respective departments. These various supervisors plan and schedule the work to the best advantage, considering the dates set for shipments, and the work already under way. Precedence or priority in the manufacturing routine may also be affected by the classification of the order, whether rush, customer or stock.

The procedure outlined uses entirely too much time of operating executives and supervisors, which is both ineffective and costly. It is important to note, also, that a good many things may happen, or fail to happen, in connection with this order because of the scattered and indefinite responsibility for it. Periodically, a check-up may be made to indicate what orders are being held up and why. Orders which are due receive the attention of stock chasers, who endeavor to eliminate delay causes and receive for such orders precedence over those less urgently needed. When a department is behind schedule this practice results in other partially completed orders being held up, slows up work, and causes confusion generally. The system puts emphasis upon pulling orders through by correcting causes of delay after they occur. Without time studies, standard task times are likely to be inaccurate or lacking altogether, and suitable employee incentives not provided. Plans fail because of lack of dependable standards as a basis for them, and a general lack of coordination.

Planning Under Functional Foremanship.—It probably will be recalled that Taylor's system of functional foremanship was designed to relieve the foreman under the line type of organization of some of the manifold duties he was called upon to perform. Taylor's first division was between the activities of planning and operation; three clerks and a disciplinarian being placed in the first group and four foremen or "bosses" in the second. The duties assigned to these three clerks—the instruction card clerk, the order of work and route clerk, and the time and cost clerk—are now largely incorporated in the production control or plan-

ning department, although the determination of costs has grown in importance from that day until it now occupies a special place of its own. The fourth member of the group, the disciplinarian, has developed into the personnel department.

Taylor recognized the need for a centralized planning body that would exercise intelligent control over manufacturing operations. From his efforts to establish a better shop organization, present-day production control has grown.

Modern Production Control.—In order to plan production in advance with certainty of accomplishment, there must be available complete and reliable data of the shop, and an organization established throughout the plant as suggested in other chapters in this book. What is known as a thorough job of industrial engineering must first be done. Then plans can be made to work. Auxiliary departments must function properly, standard conditions prevail in the production departments, task times be properly and accurately set, and worker cooperation secured.

A planning department receives accepted orders together with any instructions and specifications which may be necessary to complete them properly. When the work is of an engineering character, drawings, specifications, and bills of materials are customarily provided by the engineering department.

The functions of the department are to determine *how, when,* and *where* work is to be done, and to control it in progress. In order to do this successfully it controls, (1) manufacturing orders, (2) machinery and equipment, (3) materials required, and (4) the activities of the workers. As merely a part of the production division, the planning department possesses authority in these particulars only as necessary to facilitate production. It may not ordinarily initiate orders for changes or additions to machines or physical plant; neither may it change designs, substitute materials, or discipline workmen. It must utilize the physical plant and the human organization in doing the work designated by the orders it receives. It is a service department with very definite and limited authority. Because of its intimate knowledge of production methods and manufacturing costs, it is frequently called upon for counsel with respect to proposed new layouts, the possibility of new equipment, and to assist the sales department in estimating on new business. But its opinions on these matters are only suggestions, not orders.

Divisions of the Planning Department.—When motion and time studies are handled by a separate division of the manufacturing department, production control falls into three main activities. These are routing, scheduling, and dispatching. Most planning departments are

organized along these lines, although often other activities are also included

Routing.—The first job in planning production is to determine the way the article is to be made and the path it will travel, along with all the component parts, from operation to operation through the plant. Men who decide the route the product should follow must possess a thorough knowledge of machinery and manufacturing processes unless they are handling a standard product whose route is fixed. They must also know the equipment of the shop, the way it is being employed at present, and expected use in the near term future, and how it may be utilized for slightly different work.

Orders should be routed through the plant in the most economical way, but at times it is necessary to change the usual manufacturing procedure to provide for more even schedules, breakdowns, overloaded departments, or other reasons. Operation studies furnish the data from which the route clerks make their decisions. As the orders are received they are analyzed and the component parts determined. The proper manufacturing operations, their sequence and where they are to be performed are then established. When these are decided upon the route sheet is prepared. This route sheet forms the basis for other planning work as well as setting the path taken by the product.

Scheduling.—Scheduling consists in establishing the time each operation is to be started and finished as the order moves on its way to completion. In order to do this with any degree of accuracy time study data should be available and standard task times set.

A master schedule has to do with customer orders, orders originating from manufacturing budgets, or department activities as a whole. These are arranged in accordance with completion or delivery dates. Frequently each order or part of a customer or budget order must also be scheduled through the production processes, and this is known as a manufacturing or production schedule.

It is important that the general management, as well as the sales department, be kept informed of the demands made upon the plant by the master schedule. Production and sales need to be coordinated and the plant used to capacity in all departments. Delivery dates are always a factor in sales, and the possibility of quick deliveries in some lines may attract orders.

In making a schedule for manufacturing it is necessary to work backwards from the completion date, allowing time for each phase of the work. This may be illustrated by analyzing the production schedule for a cylinder of a tractor motor. (See Table 23.)

TABLE 23. PRODUCTION SCHEDULE FOR CYLINDER OF TRACTOR MOTOR

	Finished Tractor	Assembly	Machine Shop	Rough Stores	Purchase	Engineering
No. of days in department...	0	22	24	17	60	10
Working days ahead of completion	0	22	46	63	123	133
Date work should be finished	July 1	June 4	May 7	Apr. 7 *	Feb. 7 †	Jan. 25

* Date on which invoice should be paid. † Date on which purchase order should be placed.

This table fixes the dates and intervals for the principal events. Similar schedules must be prepared of all other assembly units. Many machine shop operations are performed in making this cylinder. There must be a working schedule which shows in detail every operation, and the date at which it will begin. Route sheets may be used for doing this. One route sheet is used for each item of product, and lists in order every operation through which the item is to pass, together with the machine, and the date on which the operation is to be performed. Progress of the work is noted by checking off each operation as it is completed. Graphic control boards may also be used which picture the planned and actual progress of each part through successive steps of manufacture. Both methods of control are adapted to single unit or assembly products. Output may be increased or decreased by varying the time interval for starting lots. An automobile company eliminates production lots and the need for much detail paper control, by simply varying the daily load of each department in proportion to the desired change in output wanted. This is done by increasing or decreasing the input of raw materials and adjusting machine capacities.

A continuous product plant, as for example a flour mill, may also vary production by changing the rate of input of raw material. In other continuous processes the speed of conveying equipment controls rates of output.

The schedule clerk arranging for production of component parts of an order must constantly have in mind the demands of the master schedule. He might readily put all parts of an order in work at the same time, but this would result in idle completed parts taking up space and adding to inventory costs. (See Figure 151A.) The logical plan is to arrange for completion of all parts at about the same time as shown in Figure 151B. For standard products, a graphic schedule may be prepared as shown by Figure 152, which shows operations and their sequence, sub-assemblies, and final assembly in relation to time.

Dispatching.—Dispatching is a clerical function which puts planning into effect. It consists in giving out the proper stores issue cards, labor

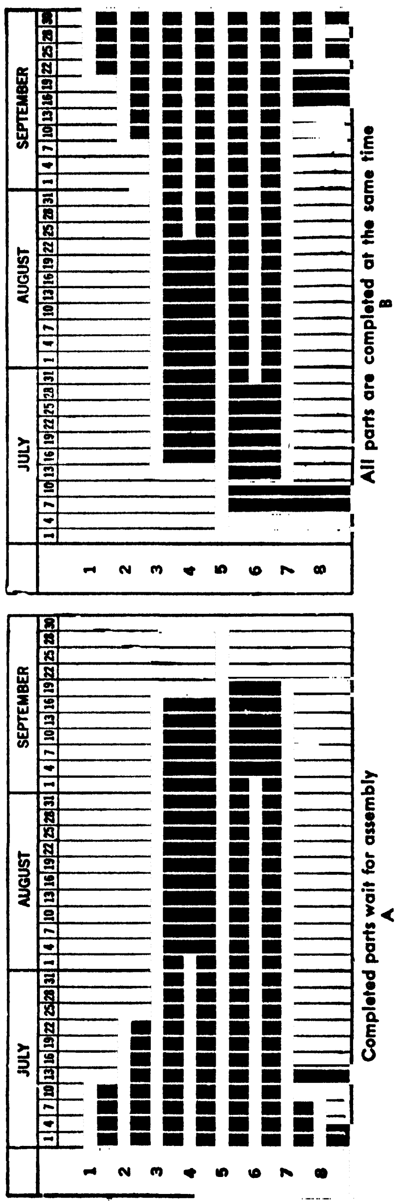


Figure 151. Two Methods of Scheduling Manufacturing of Parts of an Assembly or Order

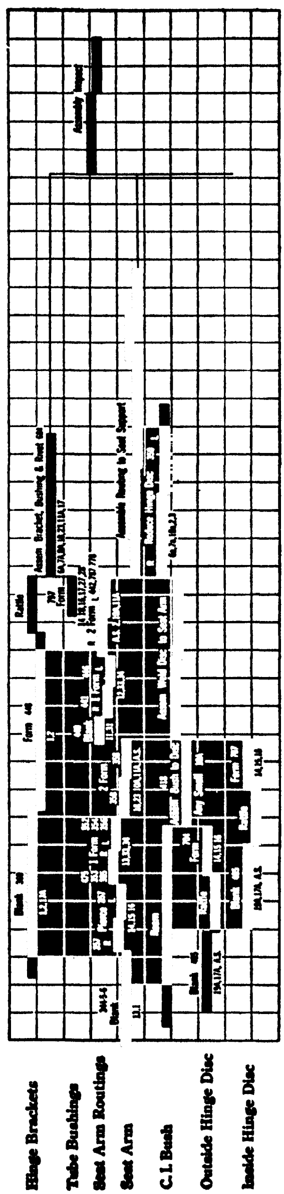


Figure 152. A Graphic Production Schedule for a Standard Assembly Product. Each space division across the chart represents a time interval.

time cards, and other control forms, so that materials will follow routes and schedules previously outlined.

When dispatching necessitates control of individual machines or work stations, planning boards may be used. A simple three-hook or three-compartment board will be described. For each machine or work station three spaces (either hooks or compartments) are provided. One is for a record of work being done on the machine, a second for job tickets of material in the department and ready to be done, and a third for jobs assigned to the machine but for which material is not yet delivered. With this board the dispatch clerk can visualize activity at all points in the shop and control production. Arranging the order in which job tickets are to be issued to a machine is a function of scheduling, but the dispatcher sees that the job is started on time.

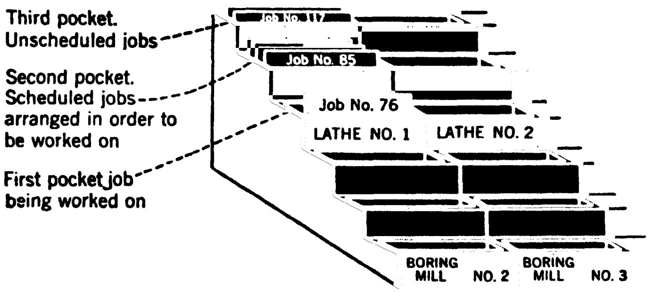


Figure 153. A Three-Compartment Planning Board

It is also the duty of the dispatching section to keep production flowing smoothly through the plant once it is started. This is done by following up the orders after work is begun, so that the schedule may be adhered to as closely as possible. When work gets behind on a certain order the dispatchers give it special attention and try to ascertain the cause of the delay and correct the situation. In many plants dispatch booths are located in the factory in or near each department so that control may be exercised on the spot.

The problems of routing, scheduling and dispatching vary greatly with the type of manufacture.

Basic Planning Data.—Basic data needed for planning include engineering drawings and specifications, parts lists, operation sheets, and information about materials on hand. Figure 65 in Chapter 14 shows an example of a manufacturing analysis of this kind which is used both in planning operations and planning the plant layout. It would be well to

refer to the description given there in connection with the subject now discussed. It will be noted that the analysis includes the following information: where the operation is to be performed, what is to be done, the tools and specifications required, machines used, raw material used, and where delivery is to be made. Frequently time values are included for each operation. Available also as a result of motion and time study will be individual instruction cards with greater details of each operation. Labor and material costs accrue from time tickets and stores issue cards to which shop burden is added, supplying information of and a check upon manufacturing costs.

TYPES OF MANUFACTURE AND PRODUCTION CONTROL

Production control problems and methods vary with the type of manufacture and with individual plants.

When parts are needed for stock the procedure is to issue production work orders or purchase orders for economic quantities, depending upon whether the parts are to be made or purchased. Figure 154 provides an illustration of a plan which will secure an even flow of orders. Knowledge of quantities needed is obtained from manufacturing schedules, then knowing the time needed to make the part, shop orders may be placed accordingly.

PRODUCTION CONTROL RECORD
NAME OF PART Coil Spring
SOURCE ______

Cost per unit ------ 0.15
Quant. for process --- 500
Deliver to dept. ------ F

PART NO.	441-S		
Used on model No.	441	941	991
No. used per model	80	80	90

Order No.	Quantity ordered	Total ordered	PURCHASE RELEASE			PURCHASE DELIVERY			DELIVERIES DEPT. F				DELIVERIES DEPT. ------				ETC.	Total scrap (re-order)
			Month	Quant.	Total	Date	Quant.	Cumulative total	Date	Quant. good	Quant. scrap	Cum. total good	Date	Quant good	Quant. scrap	Cum. total good		
126	30,000	30,000	April	5,000	5,000	4/8	4,000	4,000	4/15	898	2	898	4/25	898	3	895		3
			May	5,000	10,000	4/22	1,100	5,100	4/22	2,850		3,748	4/30	2,649	1	3,744		4
			June	5,000	15,000	5/7	4,500	9,600	4/29	1,215	10	4,963						

Figure 154. Record Form which Provides for a Continuous Balance Against Orders Ahead

(From "Production Control," by H. P. Dutton, *Factory Management and Maintenance*, Plant Operation Library.)

The block system of production control is used in garment making, and for other products which move in lots through succeeding work stations on a time schedule. If the time interval is 8 hours, each department finishes its work in that time, and thus the goods in process move uniformly ahead without congestion. Man power and equipment facil-

ities are necessarily balanced to permit this. The operation of this plan is outlined in the making of refrigerators later in this chapter.

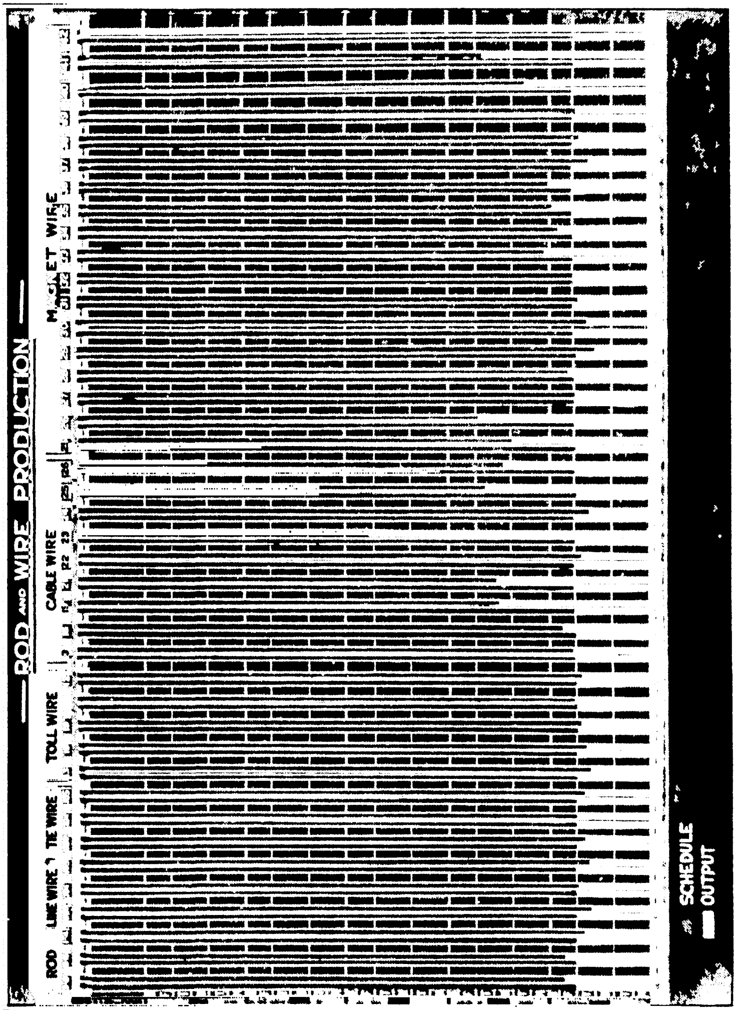
Factories differ like people, and each must be fitted individually.

Continuous Process Plants.—Scheduling, routing, and dispatching are simple problems in the making of brick, cement, the manufacture of corn starch and allied products, glass bottles, flour, pig iron, steel shapes, and many other articles. In these typical continuous process industries the raw material is a bulk material, which is carried through successive chemical or mechanical processes during its conversion into a finished product. Corn, for example, is fed into one end of the machinery, and comes out the other ends as, starches, syrups, glucose, and feeds. The fixed path of travel or flow of bulk materials, its mechanical handling, and timing of operations are an integral part of the design of the plant. Hence the route is fixed, the time in process is uniform, and the work of dispatching is simple. The only difficulty experienced is in determining the amount of sales and making production schedules conform to this.

Standard Product Plants.—Another type of manufacture from a production control standpoint is the manufacture of a standard product, such as a typewriter, lock, washing machine, freight car, or telephone. Each of these calls for the machine manufacture of unit parts from different materials. Obviously the determination of operations to be performed, the routing of component parts to various machines, and arrangements for assembly are problems which are handled by the operating management. If production is limited to a single size and style of one item, planning and control are relatively simple, but become more complex as variety is introduced in these respects, and as the list of products increases.

For any standard product a production control routine may be worked out and charted for each part, as indicated in Figure 152, which becomes standard practice for succeeding lots.

Semi-standard Product Plants.—Products which are standard in major particulars but vary in minor respects offer a more complex problem. The familiar passenger elevator affords an example of this class. Engineering design and equipment may be substantially the same for many cars which differ as to size of cab and finish, speed and distance of travel, manner of control, and safety devices. To manufacture such a product completely as a special order is to increase the cost and lengthen the time necessary for shipment. The usual custom is to manufacture for stock all standard units and a few alternate unit assemblies or parts which may be needed. Orders may then be filled from stock to



(Courtesy of The Western Electric Co., Inc.)

Figure 155. Control Board for Rod and Wire Production

meet individual specifications, with a minimum of special manufacture required. A production control system for such a plant will be similar to that described later for a jobbing machinery business. With the major part of orders stocked in advance, however, deliveries may be made much more quickly than where all parts are produced after the order is received and the production control problem simplified.

Jobbing Plants.—Firms manufacturing machinery and equipment in accordance with individual specifications need to treat each order as a special problem. The production control system must be designed to schedule, route, and dispatch each different kind of component part separately. Certain parts and units even in this field can be standardized and stocked. Differences in orders will be so great, however, that each must be considered separately and in complete detail. The same planning and control may be required for a single item of such an order that would suffice for many successive lots of a hundred or more standard parts. An example of such control will be given later in detail for the manufacture of special order machinery.

A Copper Rod and Wire Mill.—Figure 155 shows the schedule board that is used for keeping a daily check on the production of wire by sizes, against the schedules placed on the mill. This is an example of continuous production. The light lines show the proportion of the monthly schedule for all sizes of wire which should be turned out at any date and the black lines show the corresponding production. Both the lines are mounted on movable tapes and are adjusted each morning, thus giving the supervisor of the mill an up-to-the-minute picture of how the production situation stands.

A Hosiery Mill.—The manufacture of hosiery affords an example of production control methods which are generally applicable to standard

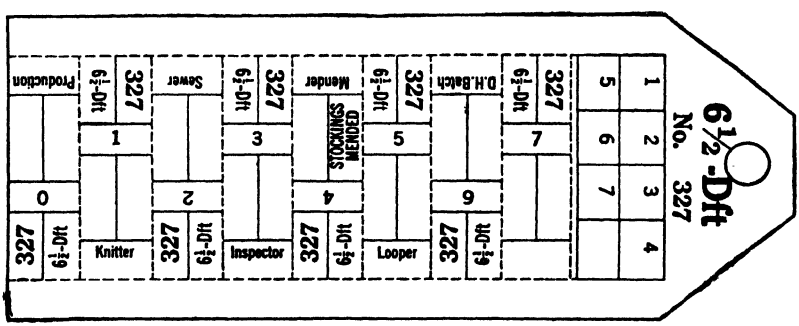


Figure 156. Example of Strip Ticket Used for Controlling the Production of Hosiery

products which pass through an established sequence of operations. A ticket as shown in Figure 156 is made out by the planning department for a standard number of dozens of a given kind and size of hose. The preparation of these tickets is based upon the master schedule of production as determined upon, considering mill capacity and the condition of the market, assuming that manufacture is for stock. When the ticket is issued to the knitting department, the bottom coupon labeled "Production" is torn off and retained in the planning office.

Receipt of the balance of the ticket by the knitting department is authority for production of the hose called for. When knit and placed in a bag the tag is attached, and coupon number one detached and retained by the operator. On the stub of the ticket in the proper place, the operator writes her number. The bag is then delivered to the sewer. After completing her task, this worker detaches coupon number two, writes in her number on the stub in the proper space and the bag goes on its way to succeeding operations, where a similar routine is enacted. The coupons provide each worker with a record of work done. If each department foreman keeps the bags moving through in proper sequence of serial numbers, there is no chance for loss or delay. Final delivery of the stub to the office informs them of the completion of the production routine for this lot and provides a record of those who performed each operation.

A Refrigerator Plant.—A manufacturer of refrigerators was enabled to increase his production by 50% and decrease unit costs by installing a planning department. Only one man is required to operate it. Figure 157a shows a graphic schedule control chart which was prepared covering the production of a standard lot of a given size of refrigerators. Operation times were set on a basis of observed times, with no attempt made to speed up production. A four-day manufacturing cycle is indicated. When a given lot is started, the material is released to succeeding operations at the times marked thus (*).

A graphic production control board is used, as shown in Figure 157b. Tacks of a different color for each lot show the scheduled starting time of the lot on each machine. A red tack is used to show the time it actually started. The planning man each night makes out the time cards for each part and each man for the next day. When he gets these cards back he checks the production against the board. If any man falls behind, his foreman is notified and relied upon to speed up the workman. For other sizes of refrigerators the number in a standard lot varies, the aim being to maintain the four-day cycle of manufacture. From experience in two departments, it is believed that when operation times are set upon a basis

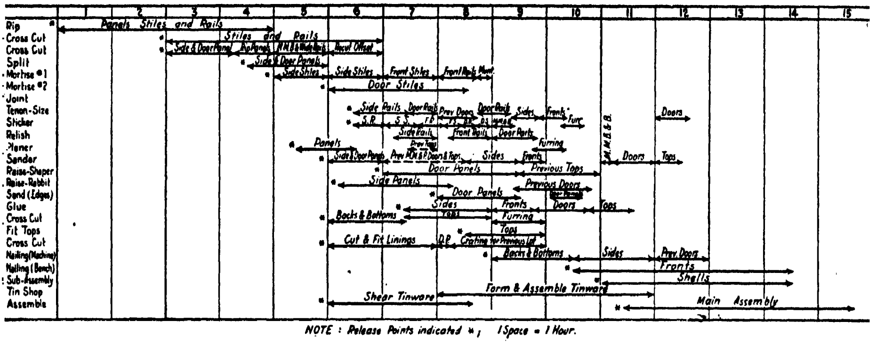
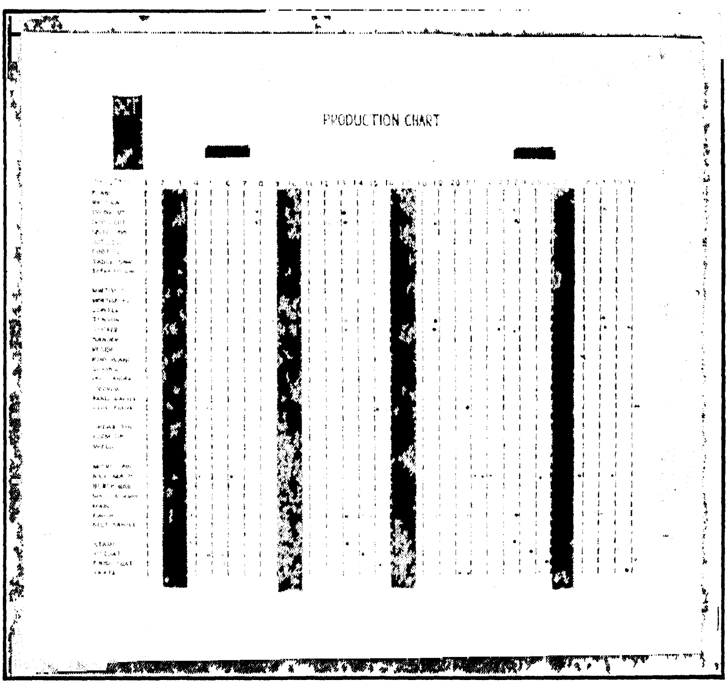


Figure 157a. Graphic Schedule Control Showing Standard Time per Part, Sequence of Parts, and Operation Release Points for a 30-Dozen Lot of Refrigerators



(Courtesy of Heinz & Munschauer)

Figure 157b Production Control Board

of time studies, and incentive wage plan introduced, the manufacturing cycle will be reduced to three days. This would give a total increase in production of 100%.

A Textile Establishment.—A plan used successfully in woolen and worsted mills possesses features which make it adaptable to production control needs in plants of widely different character. Its principal feature is a control board as illustrated in Figure 158. Goods are controlled by process rather than by customer order.

As each order is received, a ticket is made out for each piece. Tickets show style number, piece number, and date of shipment. There are

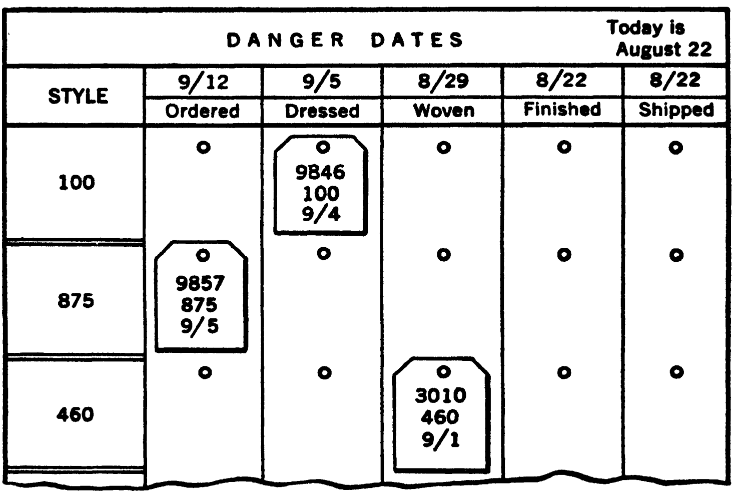


Figure 158. Planning Board Showing Checking Points and Progress of Orders by Departments

hooks on the board, and tickets are placed in the "ordered" column by style number—that is, all tickets bearing the same style number are placed on the same hook; and by delivery dates—the ticket with the earliest date is placed on top, and so on. Each day the production clerk receives a report from each department and moves the tickets from one column to the next as pieces are actually moved from one production center to another. From the board it is then possible to make out a list of all pieces that are behind schedule.

Danger dates are set to meet the mill's capacity to produce, and are moved ahead each day, the same time interval between them and the calendar date. It takes a week to process a piece through each production center. Assuming the day is August 22, a piece would need to be finished

ready for shipment on that date. If the delivery date on a ticket is the same as the danger date, the piece is on schedule; if earlier, it is behind schedule; if later, it is ahead of schedule.[1]

Manufacturing Special Order Machinery.—In the Philadelphia plant of the Link-Belt Company, Taylor and his associates installed a system of scientific management which operated most successfully. The production control system described in the following paragraphs is used today in the Chicago plant of this company, and in essentials is probably about as planned by the Taylor group.

The plan is designed to care for the production of machinery and equipment on a jobbing basis; although some stock parts are carried. The system is sufficiently flexible so that each kind of unit part of every order may be scheduled, routed and dispatched as a separate item. Orders are classified as engineering, regular, for stores, or special. A letter prefix indicates the classification. Engineering orders, or those requiring engineering or drafting work preliminary to manufacture, comprise about 90% of the volume of business. The routine of control of a typical order will be described.

Routine of an Order

1. From the office department an engineering order is sent to the engineering department, where it is divided and assigned to squads of draftsmen, each group working on a different "division" of the order. The divisions of an order are the sections into which it is divided for convenience in assigning work to the squads in the drafting department. All drawings, general and detailed, necessary for production purposes are prepared.

2. Immediately an order has been received in the engineering department, a general outline of it is prepared indicating the number of divisions into which it is divided, with a description of each. Copies of this synopsis are forwarded to the planning room, stores clerks, and various production departments as an indication to them of the work which is coming through the office.

3. This advance notice serves several purposes. It enables the stores and worked material clerks to anticipate requisitions on stocks; enables the production departments to plan ahead, provide any special equipment or facilities required, and to keep the number of employees in proper balance with the volume of production.

4. The production clerk (planning room foreman) in the planning room copies the headings of this advance notice on Figure 159 (in loose-leaf binder) in the spaces marked "Divisions."

[1] "Control Board Tells All," by R. N. Vincent, *Factory Management and Maintenance,* Vol. 92, No. 12.

AP35

ORDER NO.________ **PROGRESS OF BILL OF MATERIAL ORDER**

SOLD TO ____________________ DATE ENTERED ____________

SHIP TO ____________________ CUSTOMER'S NO. ______ TO BE SHIPPED ____________

DIVISION	Steel Hopper																							
Sheet No.	1	2	3	4	5	6	7	8✓																
Issued from Dept. DD	←				8/21			→																
Printed																								
Received by Prod. Clerk																								
Drawings Issued																								
DP Work Finished																								
Material Received																								
DM Work Finished																								
DW Work Finished																								
Received in CW																								
Shipments made																								

DIVISION																								
Sheet No.																								
Issued from Dept. DD																								

Figure 159. Progress of Bill of Material Order

5. To describe the use of this form it will be necessary to anticipate somewhat the progress of the order. As drawings are received in the planning room, the sheet numbers are noted in sequence in the proper spaces, and a check mark is made adjacent to the final sheet number for each division. This is a record that all engineering work for that division is finished. In the spaces underneath a record is kept of the progress of the work covered by each sheet as indicated by the column at the left. Miscellaneous memoranda and information pertinent to the order are noted on the sheet facing this form in the binder.

6. As progress is made with the drawings in the engineering department, those for each division of the order progressing concurrently, bills of material similar to Figure 160 are written in longhand covering each sheet as completed. These contain a description of every part of the job, item by item, in minute detail, with all dimensions necessary to manufacture each part. The prefix "R" to an item number on a bill of material indicates that it is a standard item carried in stock. When drawings are standard, bill of material sheets are provided in the form of blueprints. The parts are numbered consecutively on the drawings and these numbers form the item numbers in the "Mark" column on the bill of material sheet. To facilitate a further identification each division of the order is given a letter designation starting with "A" for the first; "B," "C," etc., for those following, as Order No. K6781A. The letter is applied as a prefix to each item number in the division as it is listed on the bill of material sheet. The engineering department supplies all data called for by this form except for columns, "Charge Symbol," "From," and "To," which are left blank. A great many sheets are often required for one order. As the bill of material sheets are completed in the engineering department, they are forwarded to the planning department.

7. The drawings are completed on tracing cloth from which blueprints are made for shop use. The tracings are preserved in the vault, and blueprints supplied to the planning room for use by the route clerk and production clerk, and for shop use.

8. By writing bills of material covering each sheet of drawings as completed, the work is fed into the shops by degrees. This tends to even the production load and avoid alternate rush and slack periods. It also results in earlier deliveries.

The Planning Room

9. The bill of material sheets are received in the planning room by the balance of stores clerk. He fills out the column "From" which indicates the source of the material to be used in completing each item, using symbols, as follows:

S —From storeroom
W—Worked material from storeroom
F —Foundry
P —Purchase order Etc.

BILL OF MATERIAL

LINK-BELT COMPANY

DD 114

WMC

WRITTEN BY		SHEET ISSUED			ORDER NO.	
KENNEDY	DRIVE & CORNER MACHY FOR 18" X 18" PECK CARRIER	Month 5	Day 21	Year 19	R 6781A	
GENERAL DRAWING		TO BE SHIPPED			SHEET NO.	NO SHEETS
C031794	CALUMET SENIOR HIGH SCHOOL-CHICAGO ILLINOIS	Month	Day	Year 19	2	

NO OF PIECES	NAME	SIZE AND DIRECTION	MARK	SHOP DRAWING	ERECTION DRAWING	MATERIAL	PATTERN NUMBER	WHERE USED	ESTIMATED NET WEIGHT	CHARGE SYMBOL	FROM	TO
1	EQUALIZING GEAR	42" P. C. 1. 57" P. 84T. 4 1/2" FACE BORE										
	CAST IRON	3 15/16" HUB 7" PROJECTS 1 1/4" ON DRAG SIDE										
		FINISHED & 5 3/4" ON COPE SIDE. ROUGH KS &										
		SS 28 DEGREE 24 MIN. BEHIND STAR. DM112C1	DIV. AR12	CS2109		C. I.	CP3851	R1 OR R2			DF	DM
1	PARL. KEY	1" X 1" X 7" FOR R12	AR13	DM112C1				R12			83	DM
2	SPROCKET WHEELS	41 1/2" P. D. 18" P. 7T BORE 3 15/16" HUB										
	FLINT RIM.	7 1/2" DIAMETER X 7" LG. 4 7/16" FROM C/L										
		ON ONE SIDE FIN. 2 9/16" FROM C/L ON OTHER										
		SIDE ROUGH KS IN LINE R&L UNDER POCKET FOR										
		ROLLER S S. DM112C1	AR14	C05946		FLINT RIM	C18072	R1 OR R2			DF	DM
2	PARL. KEYS	1" X 1" X 7" FOR R14	AR15	DM11201				R14			83	DM
		AP DDDD DD DF DF DM DW -CW								CSTGS 6/28		

Figure 160. Bill of Material Sheet

10. From the balance of stores clerk the bill of material goes to the route clerk, who fills out the column "To," indicating the department to which the material is first delivered. He uses the department symbols, as:

DM—Machine shop
DW—Fabricating shop
DC —Carpenter shop
CW—Shipping room
Etc.

11. The bill of material is then sent to the cost clerk for the charge symbol of any worked materials, stores sold, sublet, etc., of which they are keeping a special record.

12. It is then sent to the production clerk who determines the date of delivery from the foundry to the machine shop of any castings required and enters this date on the bill of material sheet.

13. In cases where the material called for is not in stock or is to be bought special for the order, the bill of material is sent to the purchasing department, which makes out purchase orders for the material marked "P" (purchase), in the next to last column.

14. The purchase department stamps the purchase order number on the bill of material opposite the item being bought. This is done so that the various departments can refer to the material by purchase order number when looking up material due.

15. The bill of material sheets are next returned to the planning room where a typist copies them in hectograph ink on form shown in Figure 160, and a number of hectograph copies are made on proper forms for distribution to departments and clerks interested.

16. Figure 160 shows a copy of a bill of material sheet for Order No. K6781, Division A.

17. Using Figure 160, the route clerk prepares a route sheet for the items listed. (See Figure 161.) Items AR12 and AR14 originate in the foundry, and items AR13 and AR15 in stores S3. This is indicated on the route sheet together with the route of the material through the machine shop. For example, the first operation on item AR12 is No. 312 and this is performed on machine No. 105. The final operation for each item is an inspection operation (ZS), following which all items are delivered to the shipping room (CW).

18. It is obvious that the route clerk must know exactly what work needs to be done on each item, the proper sequence of operations and the machines best equipped for doing them. In the case of minor assemblies, the items must be routed accordingly. All operations, machines and work places are known to the route clerks by number and are so indicated on the route sheets.

19. At the bottom of the sheet the route clerk indicates the number and kind of forms which are needed to control production of the item.

ROUTE SHEET

SHIPPING DATE ________

ORDER NO.	SHEET NO.
K6781A	2

NO. OF PIECES / MARK	NO. OF PIECES / MARK	NO OF PIECES 1 / MARK AR12	NO. OF PIECES 1 / MARK AR13	NO. OF PIECES 2 / MARK AR14	NO. OF PIECES 2 / MARK AR15
CHARGE SYMBOL	CHARGE SYMBOL	CHARGE SYMBOL	CHARGE SYMBOL	CHARGE SYMBOL	CHARGE SYMBOL
DESCRIPTION	DESCRIPTION	DESCRIPTION 42" Eq Gear	DESCRIPTION PK	DESCRIPTION 41 1/2" 7T Spkt.	DESCRIPTION P.K.
MATERIAL RECEIVED	MATERIAL RECEIVED	MATERIAL RECEIVED DF/DM	MATERIAL RECEIVED S3/DM	MATERIAL RECEIVED DF/DM	MATERIAL RECEIVED S3/DM
1	1	312 1 105	1 DMF	312 1 71	1 DMF
2	2	325 2 DMH	318 2 DZS	315 2 72	318 2 DZS
3	3	315 3 282	3 CW	329 3 123	3 CW
4	4	329 4 123	4	316 4 DMF	4
5	5	316 5 DMF	5	318 5 DZS	5
6	6	318 6 DZS	6	6 CW	6
7	7	7 CW	7	7	7
8	8	8	8	8	8
9	9	9	9	9	9
10	10	10	10	10	10
11	11	11	11	11	11
12	12	12	12	12	12
13	13	13	13	13	13
14	14	14	14	14	14
DM6 / DF32A	DM6 / DF32A	1 DM6 / 1 DF32A	1 DM6 / DF32A	1 DM6 / 1 DF32A	1 DM6 / DF32A
AP49 / 100232 CUT	AP49 / 100232 CUT	2 AP49 / 4 100232 CUT	AP49 / 100232 CUT	AP49 / 5 100232 CUT	AP49 / 100232 CUT
CS9A / DM47	CS9A / DM47	CS9A / 2 DM47	CS9A / DM47	CS9A / 2 DM47	CS9A / DM47
19765 / 100232 PERF	19765 / 100232 PERF	19765 / 5 100232 PERF	1 19765 / 100232 PERF	19765 / 4 100232 PERF	1 19765 / 100232 PERF
14229 / 14070	14229 / 14070	1 14229 / 14070	14229 / 14070	1 14229 / 14070	14229 / 14070
ROUTED DAY HOUR	TYPEWRITTEN DAY HOUR	CHECKED DAY HOUR	PRINTED DAY HOUR	WORK STARTED DAY HOUR	WORK FINISHED DAY HOUR

Figure 161. A Route Sheet for Machine Shop

Foundry Procedure

20. When castings are required, the following data sheets and forms are prepared and sent to the foundry, and constitute an order for castings. (See Figure 163.)

Bill of Material Sheet and for each item of castings

1 master time card (AP32)

is typed in hectograph ink and used to make the following:

4 time cards	(100232 cut)
1 duplicate time card	(DF32A)
1 stores issue	(19765)
1 route tag	(DM6)

Upon each of the cards appears a description of the castings required, date to be delivered to the machine shop and other information.

With these data and information the foundry office is expected to produce the castings wanted at the time designated without any further direction. In other words, the foundry handles the details of department control from its own office. A sketch of the foundry arrangement is shown in Figure 162.

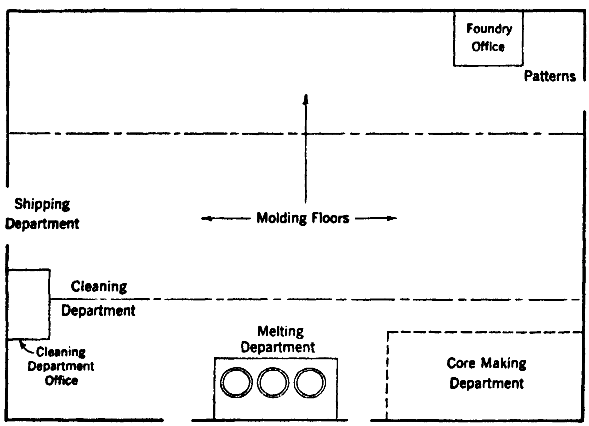


Figure 162. Sketch of Foundry Layout, Showing Principal Departments

21. Upon receipt of the above order for castings the foundry office orders the necessary patterns from the pattern department, and these are made available. Pattern numbers are supplied on the bill of material sheet.

22. Upon the time cards is stamped the following information:

Date of receipt
Kind of iron in castings
Size of core

23. Then the foundry office sends direct to the foundry cleaning room

2 time cards
1 stores issue

where the time cards are filed according to date received in a drawer corresponding to the class of order it is in, and the stores issue is filed by order number.

24. When the pattern is made available on the "bench," there are attached to it

2 time cards
1 duplicate time card
1 route tag

25. If a core is required the core maker gets one time card; otherwise it is destroyed.

26. When the molder takes the pattern, he takes a time card, and drops the duplicate and route tag in a box which indicates that the work is in operation; which fact is recorded by a mark opposite the item number on the bill of material in the foundry office.

27. The route tag and duplicate time card are then taken to the cleaning room, and attached to the time card previously sent there, which indicates that the castings are coming through.

28. The molder turns in his time card marked "finished" when he completes the task. If he does not finish the job the same day it is started the time worked is stamped on the back of the card, and it is reissued to him the following day. As soon as he completes the task, the foundry clerk so indicates by another mark on his bill of material sheet opposite the item number.

29. The actual castings will soon appear at the cleaning end of the foundry. The clerk in this department then issues to the chipper and grinder the following forms.

2 time cards (if two men work on castings)
1 route tag
1 duplicate time card

As soon as the finishing touches are put to the castings by these men in this department, they are ready for final disposition by the foundry.

30. They are weighed and the weight put on the duplicate time card. The stores issue card is taken from the file and the weight entered thereon.

31. The duplicate time card is sent to the production clerk in the planning room as an indication to him that the castings have been made, and he so indicates by a mark on the order sheet opposite the item.

32. Foundry production is kept track of by daily reports. On the sheet used are spaces for a record of the different kinds of castings produced, and for each kind, columns in which to note the order number, item number,

MASTER TIME CARD AP 32

ORDER NO. AND MARK	QUANTITY	DESCRIPTION	
K6781A AR12	1	EQUALIZING GEAR CAST IRON 42" P.D. 1.57" P 84T 4 1/2" FACE BORE 3 15/16" HUB 7" PROJ. 1 1/4" ON DRAG SIDE FINISHED AND 5 3/4" ON COPE SIDE ROUGH K.S. AND 8828 DEG. 24 MIN BEHIND STAR DM1 1201 C82109 C.1. CP3851 DF/DM 1 26	

STOPPED / STARTED		MAN'S NO.		OP'N NO.	OPERATION	CHARGE TO
		DF				

ORDER NO. AND MARK	QUANTITY	DESCRIPTION
K6781A AR12	1	EQUALIZING GEAR CAST IRON 42" P.D. 1.57" P 84T 4 1/2" FACE BORE 3 15/16" HUB 7" PROJ. 1 1/4" ON DRAG SIDE FINISHED AND 5 3/4" ON COPE SIDE ROUGH K.S. AND 8828 DEG. 24 MIN BEHIND STAR DM1 12C1 C82109 C.1. CP3851 DF/DM 1 26

DUPLICATE TIME CARD

LINK-BELT COMPANY

ROUTE TAG DM 6

Order No. and Mark	No. Pieces	Description
K6781A AR12	1	EQUALIZING GEAR CAST IRON 42" P.D. 1.57" P 84T 4 1/2" FACE BORE 3 15/16" HUB 7" PROJ. 1 1/4" ON DRAG SIDE FINISHED AND 5 3/4" ON COPE SIDE ROUGH K.S. AND 8828 DEG. 24 MIN BEHIND STAR DM1 1201 C82109 C.1. CP3851 DF/DM 1 26

K6781 AR12

1	2	3	4	5	6	7	8	9	10
312	325	315	329	316	318	CW			
105	DOTH	282	123	DOTH	223				

Figure 163. Examples of Forms Used in Connection with Orders

LABOR CARD

Cleaning	MACHINE NO OR FOUNDRY FLOOR	OP'N ______ ACCT. 3433	OPER. SEQ CE	EMP NO	TOTAL HOURS	MACH CHG.	BONUS	EARNINGS

NO. | DAY | MACH NO. OR FOUNDRY FLOOR | ORDER NO | ITEM NO | ACCOUNT OR OPERATION | EMP NO | HOURS | MACH. CHG. | BONUS | EARNINGS

ORDER AND ITEM: K6781A AR12
NO. PIECES: 1

EQUALIZING GEAR CAST IRON 42" P.D. 1.57" P
84T 4 1/2" FACE BORE 3 15/16" HUB 7" PROJ.
1 1/4" ON DRAG SIDE FINISHED AND 5 3/4" ON
COPE SIDE ROUGH K.S. AND SS28 DEG. 24 MIN
BEHIND STAR DM1 1201 CS2109 C.1 CP3851
DF/DM 1 26

Mill

15971—FRONT LINK-BELT COMPANY

PREV FIN	FIN. TODAY	CASTINGS GOOD	CASTINGS BAD	PREP.	PER PCE.	TOTAL ALLOW	TIME PREV. TAKEN	PREM. HRS.	MACH. RATE	EMP. RATE	INSTRUCTION CARD NO.

DAY	START	STOP	ELAPSED TIME	OVERTIME ALLOWANCE	TOTAL HOURS
MONDAY					
TUESDAY					
WEDNESDAY					
THURSDAY					
FRIDAY					
SATURDAY					
SUNDAY					
		TOTAL TIME TAKEN			

(Reverse of Labor Card)

STORES ISSUE

CHARGE TO	CLASS OF MAT L	QUANTITY	UNIT WT	TOTAL WEIGHT	PRICE	UNIT	AMOUNT
3433							

NO. | DAY | FOUNDRY CLASS | ORDER NO. | ITEM NO. | ACCOUNT | CLASS OF MAT'L | WEIGHT | AMOUNT

ORDER NO. AND ITEM: K6781A AR12
NO. PIECES: 1

EQUALIZING GEAR CAST IRON 42" P.D. 1.57" P
84T 4 1/2" FACE BORE 3 15/16" HUB 7" PROJ.
1 1/4" ON DRAG SIDE FINISHED AND 5 3/4" ON
COPE SIDE ROUGH K.S. AND SS28 DEG. 24 MIN.
BEHIND STAR DM1 12C1 CS2109 C.1. CP3851
DF/DM 1 26

6

Mill

115968 LINK-BELT COMPANY

FOUNDRY CLASS	BALANCE ON TAG	ISSUED BY	DATE ISSUED	REQUISITIONED BY

for Foundry Items on the Bill of Material Sheet

number of pieces and weight of each lot. The column totals and grand total give the production figures for the day.

33. In the melting department of the foundry a record is kept of the raw materials which go into the making of the castings. Comparison of these two records gives a check on daily operating efficiency, metal losses and waste.

34. From the stores issue cards a list of all castings is made each day as they go through, and this list is delivered to the planning room for the benefit of the schedule clerk.

35. The stores issue card is given to the rough stock man and accompanies the castings, to which are attached the route tag, to the receiving station in the machine shop. The clerk in charge receipts for them, sends the stores issue card to the dispatch clerk in the planning room, and the castings to the point where operation number one will be performed upon them.

36. Receipt of the stores issue card by the dispatch clerk is a signal that machine shop operations may now be started.

Machine Shop Procedure

37. For any item on the bill of material sheet which does not originate as a casting in the foundry, the following forms are made. (See Figure 164.)

1 master time card (AP32)

is typed in hectograph ink and used to make the following:

1 route tag	(DM6)
1 stores issue card	(19765)
2 transfer slips	(AP49)

and for each operation

1 time card	(100232 Perf)
1 duplicate time card *	(DM 47)

38. After the necessary cards and forms are made out the route sheet is filed at the schedule clerk's desk, where a record of the progress of work is kept.

39. All time cards, together with shop copy and move cards, go to the rate clerk to be rated. This consists in posting on the time card data in regard to pay, and indicating the instruction card and any necessary drawings which need to be issued.

40. When ready for work to begin on the item, the dispatch clerk sends the stores issue card and route tag to the stores department, which issues

* Duplicate time cards are used for posting on the planning board in the planning room while the job is being done in the shop. For short jobs they are not used.

115971—FRONT

MACHINE NO. OR FOUNDRY FLOOR	OP'N / ACCT.	OPER. SEQ'CE	EMP. NO.	TOTAL HOURS	MACH. CHG.	BONUS	EARNINGS	LABOR CARD
105	OP'N 312 ACCT.	x 1st	x			x	x	

MO.	DAY	MACH NO. OR FOUNDRY FLOOR	ORDER NO.	ITEM NO.	ACCOUNT OR OPERATION	EMP NO.	HOURS	MACH. CHG.	BONUS	EARNINGS

ORDER AND ITEM: K6781A AR12

NO. PIECES: 1

EQUALIZING GEAR CAST IRON 42" P.D. 1.57" P
84T 4 1/2" FACE BORE 3 15/16" HUB 7" PROJ.
1 1/4" ON DRAG SIDE FINISHED AND 5 3/4" ON
COPE SIDE ROUGH K.S. AND SS28 DEG. 24 MIN
BEHIND STAR DM1 1201 CS2109 C.1. CP3851
DF/DM 1 26

Premium

LINK-BELT COMPANY

PREV. FIN.	FIN. TODAY	CASTINGS GOOD	CASTINGS BAD	PREP.	PER PCE.	TOTAL ALLOW	TIME PREV. TAKEN	PREM. HRS.	MACH. RATE	EMP. RATE	INSTRUCTION CARD NO.
				20 25	1.31 1.55						

MACHINE NO.	MAN'S NO.	OP'N / ACCT.	OP'N SEQ'CE	STOPPED / STARTED
105		OP'N ACCT. 312	1st	STOPPED STARTED

ORDER NO. AND MARK: K6781A AR12 — NO. PIECES: 1 — D — PREMIUM OR PIECE WORK

EQUALIZING GEAR CAST IRON 42" P.D. 1.57" P
84T 4 1/2" FACE BORE 3 15/16" HUB 7" PROJ.
1 1/4" ON DRAG SIDE FINISHED AND 5 3/4" ON
COPE SIDE ROUGH K.S. AND SS28 DEG. 24 MIN.
BEHIND STAR DM1 1201 CS2109 C.1. CP3851
DF/DM 1 26

		DATE	HOURS	PCS. FIN.	DATE	HOURS	PCS. FIN.	DATE	HOURS	PCS. FIN.	MAN'S EARNINGS
PREPARATION											
PER PIECE											TIME CLERK / RATE CLERK / PAY ROLL

DATE	TRANSFER SLIP	BIN No.
DMF	3/6 TRANSFER SLIP AM 5th	

ORDER NO AND MARK	QUANTITY	DESCRIPTION AND ROUTING
K6781A AR12	1	EQUALIZING GEAR CAST IRON 42" P.D. 1.57" P 84T 4 1/2" FACE BORE 3 15/16" HUB 7" PROJ. 1 1/4" ON DRAG SIDE FINISHED AND 5 3/4" ON COPE SIDE ROUGH K.S. AND SS28 DEG. 24 MIN BEHIND STAR DM1 12C1 CS2109 C.1. CP3851 DF/DM 1 26

REC'D BY	ROUTE SHEET	PROD REC'D	FILE	TAKE FROM	DELIVERED TO	INSPECTOR FOREMAN
				DZ5	CW	

Figure 164. Examples of Some Forms Used in Controlling Machine Shop Operations

(For reverse of labor card, see Figure 163. Center form is copy of labor time card posted in planning room.)

the proper material to the shop. Upon notification that this has been done, the dispatch clerk may issue the job ticket (time card), for the first operation.

41. The cards for all operations on the item are bunched and placed in the compartment of the planning board which designates the machine used for the first operation. The duplicate time card for the first operation is placed in the front division of the box and the other tickets back of it. The arrangement or order of job card groups constitutes the order of work or manufacturing schedule decided upon. For each machine or work station there are provided two compartments in the dispatch box as indicated. The cards in one compartment represent jobs on that machine arranged in the sequence in which they are to be performed. The duplicate time card in the front compartment represents the job the man is working on. Cards in the rear compartment represent jobs at the machine, but the sequence in which the jobs are to be performed has not been determined. The order of jobs is regulated by the schedule clerk in accordance with the shipping dates set for the various jobs, and the necessary time for completion of parts; information obtained from the shipping board and manufacturing schedules in the planning room. Also he must endeavor to keep all machines and work stations uniformly busy.

42. The workman as he receives the time card also secures an instruction card and drawings, if such are designated. Any special tools required are also drawn. When the time card is issued the time is stamped by a time clock. When the job is completed and the card turned in, it is again stamped, and the time interval is the job time.

43. The transfer of material in work from one machine to another is accomplished by the move men by referring to the route tag attached to the material. The mechanic completing an operation places the material ready for the move man who attends to its moving without any further instruction; or his attention may be called to it. At an inspection point, or when moved from one department to another or into stock, signatures are required, and transfer slips are utilized.

44. The completion of one operation is a signal to the dispatch clerk that the labor ticket for the next operation may be issued. As each operation is completed the order of work clerk turns to the route sheet and draws a blue line through the numbers referring to it, and marks the date. When all are so marked the date of final inspection is stamped upon it.

45. Daily, all route sheets on which all items have been completed and inspected are taken from the files and sent to the superintendent, and a notification of these jobs and sheet numbers is sent to the production clerk for his information.

In this endeavor theory and ideals must give way somewhat to the exigencies of the situation. Mechanics and machines cannot be kept idle in order to postpone investment in labor costs and to have parts completed only as needed as suggested by Figure 151B. In practice it is often neces-

sary to complete parts two or three weeks before they are needed. The object of the dispatch clerk is to complete all work for which he has job tickets as quickly as possible, giving precedence to those which are entitled to it as indicated by the master schedule. Special instructions to go slow on certain jobs causes them to be used as "fillers" only.

Centralized or Decentralized Planning Departments.—Plants with acres of floor space, scores of departments and thousands of workmen suggest the difficulty of detail planning at one central point. There would be obvious difficulty in attempting to regulate the assignment of each machine in such a plant from a central office. However, in these cases master planning may be done in a central department which will schedule material to and coordinate the work of the local departments, leaving the details of production to be cared for by local planning rooms in the shop. In smaller plants it usually is possible to administer the details of planning and control more effectively from one point.

If the article is a technical one and department operation is largely independent of other departments, those in immediate charge should be best qualified to plan the work. On the other hand, if the machinery of several departments is utilized in making a variety of articles central control is essential. When a department consists of a battery of like machines, or specializes in one task, decentralized control is suggested. Routing to a group of machines simplifies control, and the foreman in charge, without need of clerical control, assigns the work to the stations or machines available. Also production delays are less likely to occur where there is greater flexibility in the use of equipment.

An important factor favoring some decentralized planning in large plants is the human element. The foreman thus has a greater share in management, which adds to his prestige and arouses greater responsibility for production. It brings management closer to the workers and makes it more personal to them. The departmental clerks act as representatives of the central planning department in coordinating department activities with the master schedule, and in reporting local progress. In fact, local control is often only nominal, but complete functionalization is modified to the extent that personal direction by the foreman is permitted when it does not conflict with the larger plan.

Graphic Control and Follow-Up.—Plans for production may be expressed in the form of charts and graphs, which show kind, quantity, cost and time schedules. As actual production takes place, accomplishment may also be pictured on the same charts. They are an excellent administrative device in enabling those responsible to keep constantly in touch with production, make comparisons, and remedy any deficiencies

which may develop before they become serious from a money or time standpoint. Charts are more easily interpreted than a mass of statistical data, portray time in relation to progress, and disclose details of operation in the shop not ordinarily apparent to higher executives. Causes and effects become immediately apparent, and responsibility for results is definitely placed. A further merit of charts is the ease with which facts are made understandable to foremen and workers. Charts picture situations as a map does the countryside.

The extent to which visual control may be used economically depends upon the cost as compared with the results secured. The continued preparation of charts, after the facts are known, may be a needless expense. They may perhaps be profitably used to disclose the nature and extent of deficiencies existing, and as a basis for applying corrective measures, when their continued preparation and use would be questionable economy. It may not be necessary to have the doctor come each day after the patient regains his health. It is true that some concerns use fewer charts today than a few years ago. However, most firms would profit by a greater appreciation of the value of presenting facts graphically. A few examples of the use of charts will be given.

The Gantt Charts.—A popular form of chart known as Gantt charts, after their originator, may be used in a variety of ways. Wallace Clark, in his book "The Gantt Chart," describes the making of these charts and indicates numerous applications. In his reface he says:

> Collectively the charts show whether or not equipment is being used at any given time and, if not, the reasons for idleness; fix responsibility for idleness and are effective in preventing it; show how the work of individual employees compares with a standard of performance and emphasize the reasons for failure, thus fixing the responsibility for the removal of those obstacles; enable the work to be readily planned so as to make the best possible use of available equipment and to get work done when it is wanted.

These charts show the load of work planned for a whole plant or an entire industry, give a continuous comparison of performance with schedule, and make it easy for an executive to foresee future happenings with considerable accuracy and to overcome obstacles more easily.

Figure 165 shows a Gantt layout chart for a machine shop. Angles opening to the right and left, respectively, show planned time for beginning and completion of the job. The heavy line is drawn on the chart, as daily reports are received and show progress. Delays are indicated by light lines drawn below and at right angles to the heavy line, marked

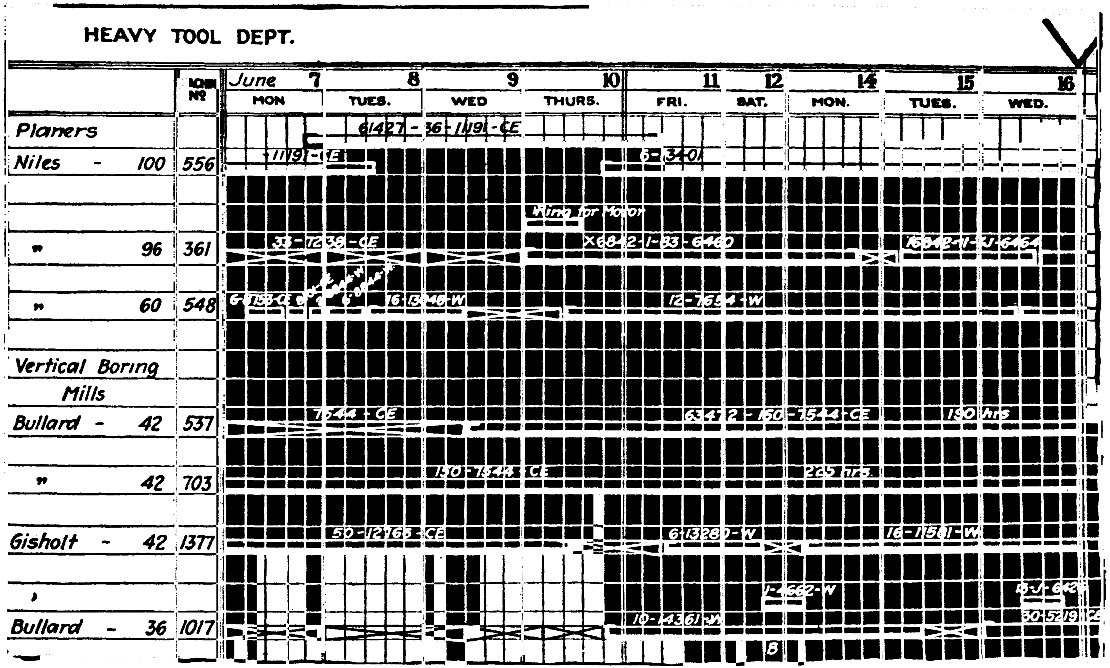


Figure 165. Gantt Layout Chart for Machine Tools

Date job is scheduled to start.
Date job is scheduled to be completed
Total time scheduled for order.
Work done.

Time required to make up for past delays.
Figures above lines indicate order numbers.
Indicates that chart was reproduced Wednesday night and shows how the work stood at that time.

Reasons for stopping work: *B*—Break-up. *H*—Lack of help. *M*—Lack of material. *P*—Lack of power. *R*—Repairs. *T*—Lack of tools.

by symbols, as "R" for repairs; "M" lack of materials; "T" lack of proper tools; "B" breakdown; "H" shortage of help; etc.

Orders received are broken down into machine operations, and their sequence is noted. The first operation is laid out on the layout chart opposite the machine to be used. The machine record for the second operation is then looked up, and the operation laid out on the chart. This procedure reserves the machine in question for the particular job, and prevents assignment of two jobs to any one machine for a given period. Daily reports of progress aid the planning clerk in keeping work properly scheduled.

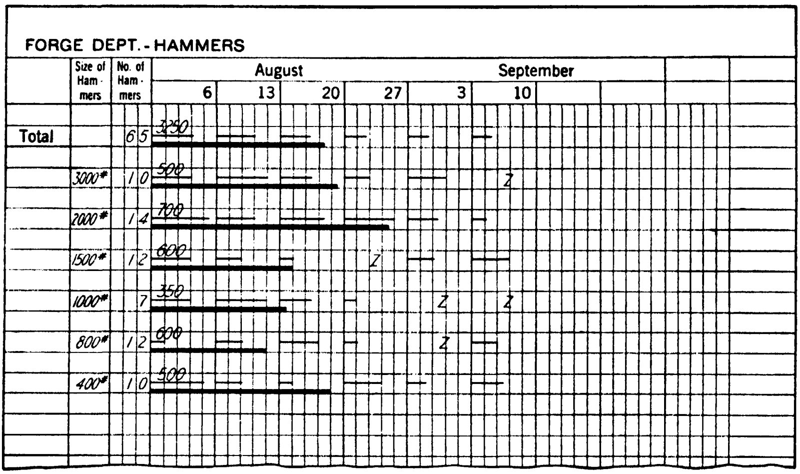


Figure 166. Gantt Load Chart for Drop Forge Hammers

On the Niles planer number 556, job No. 11191-CE, was scheduled to be completed Tuesday noon, but was completed ahead of time and another order, No. 61427, started upon it. This job was also finished ahead of time, and a third job was begun Thursday afternoon instead of Friday. When the chart was copied on Wednesday, the 16th, the work was just on schedule. On the second machine, the work was already 3 days behind schedule when it was carried over from a previous sheet. At that time job No. X6842 was scheduled to begin Thursday morning and be completed Monday afternoon, but it was necessary to run in a repair job, a ring for a motor, so that 4 hours had to be allowed for the delay (indicated by the crossed lines) before job No. 16842 could start. Work on this machine was 4 hours behind schedule when the chart was copied Wednesday night.

A Gantt load chart for a forge shop is shown in Figure 166. The number of hammers in each size class are indicated in the column at the left. The chart is based on a 50-hour work week. For the seven 1,000# hammers this would give a weekly capacity of 350 hammer-hours, as indicated by the figures in the adjoining column. The light horizontal lines show the amount of work scheduled during the respective weeks. With five vertical divisions in each week column, a line across three divisions in the column for the week ending August 6 opposite the 1,000# class indicates that 210 hours of work have been scheduled for that group during that period. The total work scheduled for each group is indicated by the corresponding heavy line, which is in each case a summary of the light lines. A space marked Z indicates no work scheduled during that weekly period.

Reference to the chart will quickly indicate to the route clerk or foreman the amount of work ahead for each size of hammer, and facilitate the task of keeping the department busy but not overloaded at any point. The use of equipment is shown clearly, and as a consequence the investment in expensive machinery may be reduced.

CHAPTER 33

INDUSTRIAL COSTS

The Need for Accurate Costs.—In order that business may be conducted successfully it is essential that the costs of production and selling be known. This is particularly true in a system of competitive economics where profits are dependent upon keeping monetary costs below selling prices, but it is also important when only the economic costs of labor and capital are considered. In an effort to raise the standard of living in any society the expenditure of human energy, time, materials, and machinery should not be wasted. The only exact way to know whether waste is present is to compile cost data and make comparisons with other methods. Cost accounting is a tool of management which, when rightly used, will point out the results of operations and indicate needs for changes or corrections.

Frequently there is an erroneous belief that the main purpose of cost accounting is to determine the selling price of the product. While selling prices are to some extent based upon costs of production, this is by no means the whole story. Prices are also determined by the existing demand and the possibility of substituting competing products. The major use of cost figures is to ascertain the costs of the various items of expense and to demonstrate ways in which waste may be eliminated by making all expenditures more effective.

A good cost system should accomplish the following:

1. Act as a guide to the economy and efficiency of work.
2. Keep track of investments in inventories.
3. Control scrap and defective work.
4. Indicate inefficient use of existing equipment and requirements for additional equipment.
5. Help in controlling overhead expenses.

Cost records can point the way, but they are of no avail unless management takes steps to put into effect the action indicated. Like the other control devices previously discussed, the determination of costs solves no problem in itself. That is the task of intelligent management, and it cannot be relieved of the burden.

Elements of the Cost of Production.—The selling price of an article is made up of a number of different costs and expenses which may be divided into (1) manufacturing costs, (2) general expenses, and (3) profit. The first, or manufacturing costs, will be considered in this chapter. General expenses cover what are known as administrative and selling expenses. These include such items as office salaries, repairs, and maintenance to all buildings other than shops, contract and sales department, branch offices, shipping room, etc.

The items which go to make up the cost of manufacturing an article are: (1) the cost of materials; (2) direct labor costs, and (3) shop expense or burden.

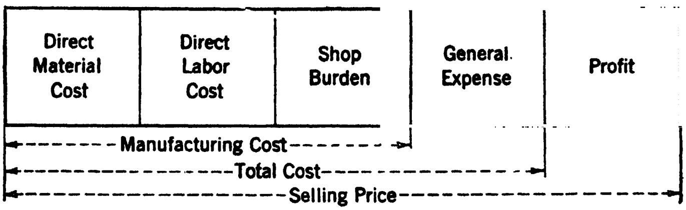


Figure 167. Elements of Selling Price

Material and labor costs may be classified as to whether they are direct or indirect. All materials which enter directly into the making of a finished product in such a way that the amount and the cost can be accurately allocated to each unit or job, are called direct materials. It is not always easy to determine the exact quantity of materials used per unit of product, as, for example, in the case of stains and varnish in furniture manufacturing. Where very small quantities of materials enter into products, the cost of keeping the accounts might be greater than the cost of the materials themselves. In most cases, however, the cost of the direct material can be determined very accurately. The many other materials used to carry on manufacturing processes such as oil, waste, and miscellaneous supplies are called indirect materials.

Direct labor cost consists of wages or salaries paid to those who work directly upon the product. It is evident that a considerable number of people employed in manufacturing departments contribute to production by indirect labor, such as foremen, truckmen, oilers, repair men, clerks, etc. The wages paid to such individuals are classified as an indirect labor cost. Indirect labor and indirect material costs, along with other expenses such as depreciation, repairs, and supplies, are combined under the name of shop expense, overhead, or burden.

The simplest parts of the problem are to allocate the cost of materials used in the finished product and to ascertain the amount of direct labor expended in making a unit of it. Greater difficulty is involved in the distribution of shop expenses, so that each unit will bear its proportionate share. If the factory made only one product without variation as to style, quality, kind, or size, the unit cost could be determined simply by dividing the total cost by the number of the units made. However, in most industries today the problem is complex, involving not only many different sizes, kinds, and styles of one product but different lines of products.

Methods of Distributing Shop Expense or Burden—Direct Labor Hours.—Using the labor hours method, the total number of hours employees work on a job is taken as a basis for distribution. The rate to be applied is determined for a given period for each department or sub-department, by dividing the estimated burden at normal production by direct labor hours at normal production. This gives a standard burden rate. The burden charge for a given job is determined by multiplying the labor hours by the standard burden rate. An example will illustrate the method:

Burden rate, per man-hour..........................	$ .50
Number of man-hours used..........................	250
Burden chargeable to the job is:	

$$250 \times \$.50 = \$125$$

The plan has inherent defects which make it inaccurate for many installations. The finding of the rate deals with two variables, total expense and labor hours, hence it is not accurate. Further, one mechanic may operate an expensive milling machine, while another uses a small emery wheel. The former may cost $10,000; the latter, $100. It may cost $2 an hour to operate the milling machine and but 15¢ an hour, or less, to operate the emery wheel. The method does not allow for idle machine time, and gives but an average distribution. The expense charge is greater on a job performed by a slow workman than an equal task performed by one who is more skilled. Jobs which consume the same amount of shop time receive like expense charges, although the wages paid and the nature and extent of equipment used may vary greatly. The method is best adapted to departments or plants where the equipment used and lines of products made are similar in size and character.

Distribution of Burden—Direct Labor Cost.—This method is similar to the labor hour method, except that the rate is determined by

dividing the estimated shop burden for a period of normal production by the estimated cost of direct labor for the same period. The plan operates as follows:

Estimated direct labor payroll....................	\$16,000
Estimated shop expense..........................	14,000

$$\text{Burden rate} = \frac{14{,}000}{16{,}000} = 87\tfrac{1}{2}\%$$

Then if the direct labor costs on a job amount to \$16, the shop burden will be:

$$\$16 \times 87\tfrac{1}{2}\% = \$14$$

The rate is obviously but an approximation and an average. The same general defects may be noted in this method as in the labor hour method. It operates inaccurately when machine operation costs vary, as they do with a variety in size and kind of equipment. In the example of the milling machine and the emery wheel the operators might receive the same wage per hour, and hence the expense charge be the same per hour, when actually the figures should be quite different. When several lines of products are turned out, a falling off in some lines will shift the burden of shop expense to the others, and if differences in size are considerable, this may add a disproportionate burden of interest and fixed expenses to them. Shop expense for parts handled on a bench is much less than for items which occupy perhaps 100 square feet and require overhead crane service. The method ignores the time element, always important in shop costs. It is best suited to operations where labor is the dominant element and uniformity prevails with respect to product, wages, and equipment.

The plan is used more effectively when work is departmentalized according to size as well as kind of equipment, which is the practice in some large shops. A large machinery manufacturer producing on a jobbing basis uses the plan as modified in the following manner. The total shop expense for a period of three years is apportioned to the different departments in proportion to the amount incurred by each. The amount for each shop is then divided by the total direct wages in the shop for the same period. In this way a different rate is obtained for each shop. For example:

Pattern shop	60%
Heavy machine shop	75%
Light machine shop	50%
Structural shop	70%

The rate in the heavy machine shop is again modified to fit the work. For some work of a standard, repetitive character, as gear cutting for

silent gears, one mechanic operates several machines. Since the rate is applied on the basis of direct labor, the expense charge would be very small, and not at all in harmony with the value and operating costs entailed by the machines used. Hence, the rate is arbitrarily increased for this class of work. The same reasoning is applied to other classes, and adjustments are made accordingly. Care must be used that the total expense credits which accrue by application of the adjusted rates give an amount equal to the charges apportioned to the department. Without careful modification in this way the plan is not suited to diversified production.

Distribution of Burden—By Output, or Material Used.—The volume of output may be used as a basis for the distribution of expense. The basic idea involved in this method is that the expense is proportionate to output, and it is applicable accurately only when this is true. It is practicable, therefore, when tools, machines, and equipment used vary directly with the volume of material, and the product is uniform and output fairly constant. This situation obtains in continuous process industries like the making of brick, cement, corn products, and in lumber mills and salt works.

Assuming that a rate of \$25 per thousand units has been set, the expense charge on an output of 4,200 units would be:

$$4{,}200 \times \frac{\$25}{1{,}000} = \$105$$

The method can also be applied on a basis of direct material used, considering either quantity or value.

Distribution of Expense—By Machine Hour Rate.—There is a direct connection between the cost of running a machine and the amount of the work done by it. It costs more per hour to operate a large gear planer than it does to operate a small drill press, and it is possible to analyze the expenses of operation into definite measurable factors. Some of these, such as small tools, depreciation, and power, are chargeable directly against individual machines. Others, such as light and heat, need to be prorated over all machines and processes in a department. A total of all the estimated charges against a machine for a period of normal production, divided by the estimated number of hours the machine will run, gives the standard machine hour rate.

In many shops the number of hours which a machine will be used during the year may be an uncertain figure. A certain amount of idleness is inevitable due to lack of orders, necessary repairs, and absence of operators. Ordinarily, however, a machine should be in operation 80%

or 85% of the time the shop is running. Thus for a shop working 8 hours a day, after allowing for holidays, etc., 2,000 hours might be used as a base figure. If the machine is not used as much as estimated there will be some expense which will not be charged off at the end of the period, while if the machine is used a greater number of hours, a surplus will accumulate. In either event an adjustment will need to be made. A simple method is to transfer any differences into a separate account, where they will tend to balance each other. At definite periods any balance in this account can be transferred to profit and loss. Any considerable variations from the expected are cause for revising rates.

This method of expense distribution is more accurate than the others described, particularly in departments using costly machines. It is especially applicable where machine operation is the dominant factor, and the idle time is small. The rate fails to care for idle time, and in dull times it is the large costly equipment which is idle most. In departments where much hand labor is used, the machine hour rate is not satisfactory. The present practice of cost accountants is to use both a direct labor rate and a machine rate in many departments. Such burden as power, depreciation, insurance, etc., is applied by the machine rate; supervision, heat, light, and the like by a direct labor rate, either on a basis of cost or direct by labor hours.

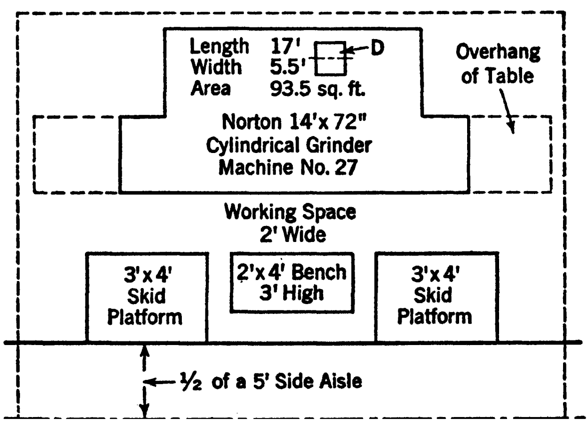


Figure 168. Layout of Production Center for a Norton Cylindrical Grinder

Calculations for a rate to cover a group of Norton cylindrical grinders will illustrate the application of the method. Figure 168 shows the working arrangements and floor space required for each machine, and Figure 169 the group layout. In addition to the floor space actually

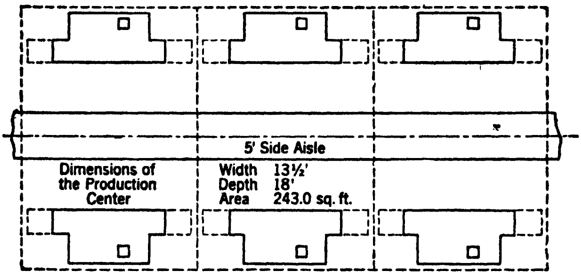


Figure 169. Layout Arrangement for a Group of Six Norton Cylindrical Grinders Showing the Location of the Machines and the Size of the Production Centers

occupied by the machine there must be space for the auxiliary tools and equipment, room for the incoming and outgoing material, as well as working space. This total area is called a production center, and this method of distributing burden is often called the production center method.

1. Tabulation of Data

Working area of one machine (a production center)	243 sq. ft.
Present value of one machine (new)	\$3,300
Rated horsepower of machine	10
Number of machines in group	6

2. Estimated Number of Hours of Operation

This factor is estimated from past records and from estimated orders unless the output is accurately known. A total number of hours of operation of 934 per month will be assumed for the group of six grinders.

3. Floor Area Chargeable to the Group of Machines

Area of the six production centers is 1,458 square feet. In addition to this area a part of the main aisles, foremen's and superintendent's offices, storerooms, etc., must be charged to this group.

Total area of shop	92,600 sq. ft.
Total area of production centers	51,200 sq. ft.

Floor space factor, $\frac{92{,}600}{51{,}200} = 1.81$

Floor area chargeable to the group of grinders
$= 1{,}458 \times 1.81 = 2{,}639$ sq. ft.

4. Power Cost per Month, per Group

The department power feeder lines are connected separately to the switchboard of the power plant and the machines are all driven by individual motors. Hence it is possible to determine the average amount of power used by this department. By prorating this quantity against each machine of the department on the basis of the size of the motor, it is possible to find the approximate cost of power for each machine.

Average power load for the department[1] = 210 kw.
= 282 hp.

Total rated capacity of all motors in the department = 625 hp.

Average consumption of energy $= \frac{282}{625} =$ .451 hp. per rated hp. of motor.

The 10-horsepower motor on each Norton grinder uses only 4.51 horsepower on an average, as the motor only occasionally runs under full load.

Horsepower-hours per month, per group

$$10 \times .451 \times 934 = 4{,}210 \text{ hp-hr.}$$

Cost of power is 1.75 cents per kilowatt-hour, or 1.305 per horsepower-hour. Therefore, the power cost for the six grinders for the month is

$$4{,}210 \times 1.305 = \$54.90$$

5. Supervision and Miscellaneous Charges per Month per Group

Supervision including foremen, helpers, move men, time clerks, tool room attendants, etc.	$3,500
Department supplies	500
Other miscellaneous expenses	750
Total	$4,750

Total estimated hours that all of the machines in the department will operate per month = 42,500 hours.

$$\text{Charge per hour} = 4{,}750 \div 42{,}500 = .118$$

Number of hours that the group will be in operation per month is 934 hours. Then $934 \times .118 = \$110.21$.

[1]Power is supplied in kilowatts. 1 hp. = .746 kw.

6. Space Charge per Month per Group

Cost of buildings	$575,000	
Cost of land	15,000	
	$590,000	
Cost of furniture, fixtures and all equipment except machinery	150,000	$740,000.00
Taxes on plant (on $740,000) per month		1,233.33
Interest on plant ($740,000 at 6%) per month		3,700.00
Insurance on plant ($740,000 - 15,000) per month		3,927.08
Water and heat per month		750.00
Light per month		300.00
Depreciation on buildings per month:		
(a) Building No. 1 and No. 2 (mill construction)		810.00
(b) Building No. 3 (steel construction)		725.00
Depreciation on furniture, fixtures and equipment per month		1,135.00
Total		$ 12,580.41

Space charge per month per group:

$$\frac{\$12{,}580.41}{92{,}600 \text{ (total floor area of plant)}} = \$.136 \text{ per sq. ft.}$$

Floor area chargeable to the group of Norton grinders = 2,300 sq. ft.
Space charge = 2,639 × $.136 = $358.90

7. Individual Production Center Charge per Month per Group

Value of 6 Norton grinders = 6 × $3,300	$19,800.00
Interest on $19,800 at 6% per month	99.00
Taxes on $19,800 per month	33.00
Insurance per month	74.10
Repairs and maintenance per month	16.80
Total	$ 222.90

8. Depreciation per Month per Group

Cost of 6 Norton grinders (new) = 6 × $3,300 = $19,800
Estimated length of life = 15 years
Scrap value of six machines = 6 × $250 = $1,500
Depreciation per month by the straight-line method =

$$\frac{\$19{,}800 - \$1{,}500}{15 \times 12} = \$101.60$$

9. Calculation of the Machine Hour Rate

(a) From item 4—Power cost per month per group	$ 54.90
(b) From item 5—Supervision cost per month per group	110.21
(c) From item 6—Space charge per month per group	358.90
(d) From item 7—Individual production center charge per month per group.............	222.90
(e) From item 8—Depreciation per month per group	101.60
Total charge per month per group......	$848.51

$$\text{Machine hour rate} = \frac{\$848.51}{934^*} = \$.9085$$

Machine hour rate = \$.9085

Abnormal Expenses Charged to Management.—In many cases more efficient management may be promoted if methods of measuring production costs are used whereby expenses are divided into two classes, depending upon whether they are fixed or variable. If the output of the department is decreased one-half, the variable expense will in like manner be cut in half, but the fixed costs will not change. If there is a lack of orders and equipment is not used to capacity, or if a more expensive machine or class of labor is used than is normal, then these facts should appear on the books in such a way as to show the true conditions, and not place responsibility upon the manufacturing superintendent, for he is not responsible. It frequently happens that sales trends tend to place abnormal demands on particular manufacturing departments or classes of machines, and leave others comparatively idle, unless used at a disadvantage. In order to increase outputs, operations may be performed on machines which can do the work, although uneconomically. The consequence is to decrease profit, or even incur a loss. The remedy is to sell what the plant can produce to advantage.

Accuracy and fairness would seem to indicate that the expense charged to a product or order should bear a definite relation to the use made of manufacturing arrangements. Manufacturing costs would not fluctuate with a varying volume of output if this were done, and undistributed fixed expense would be charged to the profit and loss account. This would constitute a charge against management for failure to utilize its plant normally.

* 934 is the estimated number of hours that the machines in this group will run per month.

Theoretical and Practical Capacity.[2]—Theoretical capacity may be stated as the number of units a given piece of equipment or machine can produce within a given time under ideal conditions. In connection with hand labor it implies the number of units that *can* be turned out by the best workers. Practical capacity, on the other hand, is commonly regarded as a percentage of theoretical capacity. That is, allowance has been made for single purpose equipment, unusable equipment, emergency machines, etc., and in the case of hand labor for losses attributable to labor turnover, absenteeism and the like.

The effect upon the burden rate is illustrated by the following figures:

Factory Operating Condition At:—	Monthly Production	Unit Burden
(1) Practical capacity (as previously herein defined)	1,000	$2.00
(2) Highest sustained rate of production (experienced for one month during a good year).....	900	2.22
(3) Average production over several months of regular operation when sales volume was sufficiently uniform to warrant efficient operation.........	800	2.50
(4) Monthly production during a year when the most uniform production was maintained throughout the year	700	2.85
(5) Average monthly production during the previous year	600	3.33

The nearer production can come to (1) the closer costs are to their low. Probably a point somewhere between (2) and (3) may ordinarily be chosen as a base.

The effect of this "variance" in the burden rate due to different volumes of output when actual costs are used is disclosed by the following analysis:

1. Units produced sell at $5 each.
2. Fixed factory charges are $1,000 per period.
3. Variable factory expenses amount to $3 per unit produced.
4. Selling and administrative expenses amount to 8% of sales income.
5. An inventory of 200 units is carried on hand at all times.

In the period just prior to the first one shown in the following table 1,000 units had been produced at a cost of $1,000, the fixed expense, plus $3,000 the variable expense ($3 times 1,000), making a total cost of $4,000 or $4 per unit. The opening inventory of 200 units is therefore worth $800.

[2] "Normal Capacity and Its Relation to Costs," a booklet issued by the Illinois Manufacturers' Costs Association, Chicago.

Period	1	2	3	4	5
Units produced	800	600	600	700	700
Actual unit cost	$ 4.25	4.67	4.67	4.43	4.43
Opening inventory	$ 800	$ 850	$ 933	$ 933	$ 886
Add manufacturing expenses	3,400	2,800	2,800	3,100	3,100
	4,200	3,650	3,733	4,033	3,986
Less closing inventory	850	933	933	886	886
Cost of sales	3,350	2,717	2,800	3,147	3,100
Sales income	4,000	3,000	3,000	3,500	3,500
Gross profit	650	283	200	353	400
Selling and administrative expense	320	240	240	280	280
Net Profit	$ 330	43	40*	73	120

* Denotes loss.

Note that although the operations in the third period were carried on at the same volume and according to the original assumptions at the same efficiency, still, with the same administrative and selling expense, the third period shows a loss whereas the second shows a profit. Obviously, this is misleading. Likewise, one might erroneously gather that the fifth period operations were in some way more efficient and therefore more profitable than those of the fourth period.

When operating statements are computed on a standard cost basis, these peculiarities do not occur. Take, for example, the conditions assumed above and add the assumption that 1,000 units per period is the basis upon which standards are computed:

Period	1	2	3	4	5
Units produced	800	600	600	700	700
Manufacturing expense	$3,400	$2,800	$2,800	$3,100	$3,100
Standard cost of production	3,200	2,400	2,400	2,800	2,800
Sales income	4,000	3,000	3,000	3,500	3,500
Gross profit	800	600	600	700	700
Idle plant expense	200	400	400	300	300
Selling and administrative expense	320	240	240	280	280
Net Profit	$ 280	40*	40*	120	120

* Denotes loss.

The second and third periods now show identical losses and the fourth and fifth periods show identical profits.

Depreciation.—The elements entering into depreciation charges are: (1) cost, (2) estimated useful life, (3) scrap value, and (4) repairs and replacements. A machine worth $2,500 today may be worth but $1,000 in five years. As fiscal periods do not coincide with the life periods of machines, buildings, and equipment, it becomes necessary to compute depreciation at periodic intervals.

Depreciation charges are sometimes figured as an estimated percentage of the cost or book value of the assets. These may be classified under appropriate headings as buildings, machinery and equipment, furniture and fixtures, and the like. Charges are then made up by taking an arbitrary rate of from 1½% to 5% for buildings, 5% to 15% for machinery and equipment, and from 7½% to 33⅓% for furniture and fixtures. While this method may answer under some circumstances, it is not to be recommended. It is usually desirable to consider depreciation on individual machines, buildings or other asset units.

Depreciation charges cannot be determined with absolute accuracy. They are occasioned by wear and tear, by other causes not remediable by repair and maintenance work, obsolescence and inadequacy. Machines and buildings tend to wear out. By maintenance and repair work it is possible to prolong the life of the asset, but there will come a time when it will not serve its purpose. The mere passing of time may cause assets to waste away. Unused buildings and equipment may depreciate more rapidly than if used. Obsolescence has to do with type and quality. It is a cause of value depreciation in that an asset may decrease in value because of some new development. A new machine or process may be invented which will render other machines useless. Newer methods may be more economical, for example, making it advisable to scrap present equipment for more modern machines. This factor has been a prominent one in the textile, shoe, and Portland cement industries, and in the earlier development of industries based on the use of electrical equipment. Equipment which is in good condition may be discarded because it becomes inadequate with respect to size or power. Public utilities are constantly confronted with the fact that turbines, boilers, transformers, etc., become too small. Larger units are frequently installed because of the increased efficiencies derived by their use, while extensions of power lines or transportation facilities into rapidly expanding communities necessitate replacement of existing equipment on a larger scale or installations not immediately fully utilized.

Repairs, Renewals, Replacements, and Depreciation Rates.—Repairs, renewals, and replacements are factors entering into the determination of rates. There are three methods of handling charges from these needs:

1. The expense may be charged to operating cost as incurred.
2. The annual charge expected may be estimated, and a reserve accumulated in a reserve account by credit each month of 1/12 the total. Against this account charges can be made as they occur.

3. In the beginning, an estimate may be compiled to cover the cost of repairs and renewals, and this amount added to cost of the item. The depreciation rate can then be calculated high enough to include such expenses. As they occur they can be charged against the depreciation reserve.

It is considered best practice in most cases to charge to operating costs expense of this kind as it occurs. When for some reason such charges are unusually heavy at certain periods, the second plan suggested may operate more smoothly from a financial standpoint. The main object of the third plan is to equalize the annual charge against revenue to cover depreciation, repairs, and renewals. In the later years of the life of a machine or building these latter expenses would tend to be much greater than in the earlier years unless handled in this way.

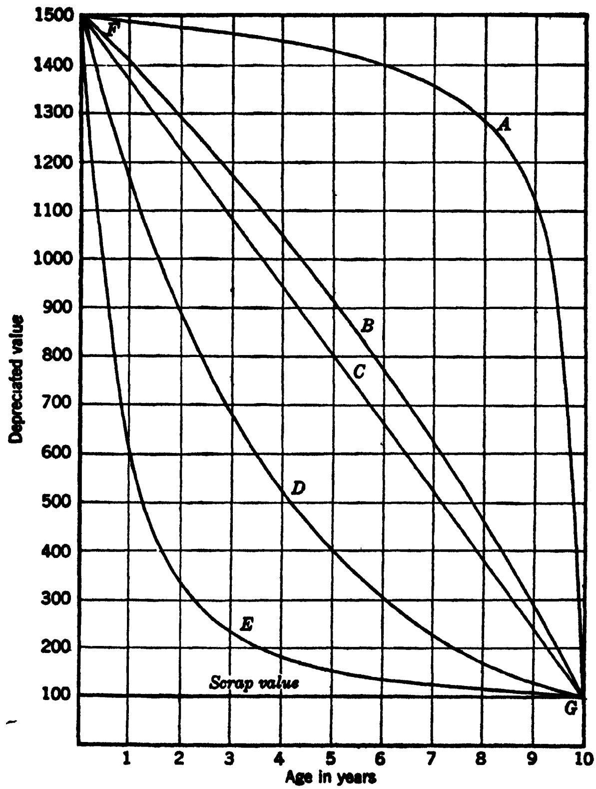


Figure 170. Chart Showing Depreciation Charges as Computed by Different Methods

Methods of Calculating Depreciation.—It may be contended that the resale value is the only true value of equipment at a given time. On this basis a slightly used machine may be worth little more than half of its cost. With this assumption depreciation would take place very rapidly at the beginning of the period of use and less rapidly during the later life of the machine. This is shown in Figure 170 by curve *FEG*. From the standpoint of serviceability it is evident that the machine would be just as good as new for a good part of its early life. On this basis there would be but little depreciation during the first period. Curve *FAG* of Figure 170 illustrates the effect of this reasoning. Methods which are less extreme and more practical are the (1) straight-line method, (2) sinking fund method, (3) reducing balance method, and (4) production method. The data used in plotting the curves in Figure 170 are given in Table 24.

The graphs in Figure 170 disclose that the straight-line method (line *FCG*) is more conservative than either the sinking fund method (curve *FBG*) or considering actual value from a service standpoint (curve *FAG*). Because of this, and on account of simplicity of calculations with this method, it is the one most generally used.

TABLE 24. DEPRECIATION DATA USED IN PLOTTING CURVES IN FIGURE 170

Age in Years	Straight-Line Method		Sinking Fund Method		Reducing Balance Method	
	Depreciated Value	Yearly Depreciation	Depreciated Value	Yearly Depreciation	Depreciated Value	Yearly Depreciation
0	$1,500.00	$ 0	$1,500.00	$ 0	$1,500.00	$ 0
1	1,360.00	140	1,393.79	106.21	1,144.05	355.95
2	1,220.00	140	1,281.21	112.58	872.57	271.48
3	1,080.00	140	1,161.87	119.34	665.51	207.06
4	940.00	140	1,035.37	126.50	507.58	157.93
5	800.00	140	901.28	134.09	387.13	120.45
6	660.00	140	759.15	142.13	295.27	91.86
7	520.00	140	608.49	150.66	225.21	70.06
8	380.00	140	448.79	159.70	171.77	53.44
9	240.00	140	279.51	169.28	131.01	40.76
10	100.00	140	100.07	179.44	99.93	31.08

Standard Costs.—Standard costs provide an effective means of managerial control. They are planned costs which serve the same as a budget in setting standards of achievement and providing a check on attainment.

They point out any discrepancies that may occur and indicate conditions that require attention. While the fundamental principles of standard cost systems are essentially the same, each installation must be individually adapted to the situation. The Cost and Production Handbook lists causes of variations in production costs due to various reasons. Variations in labor costs are due to:

1. Poor selection of workers.
2. Inadequate or incorrect training.
3. Poor wage or incentive payment plan.
4. Lack of suitable machines, tools, equipment, or materials.
5. Changes in design of product.
6. Changes in machinery, tools, equipment, or methods, or specifications.
7. Unsatisfactory working conditions.
8. Dishonesty among workers or collusion with supervisors.
9. Increased wages or working hours.
10. Excess supply and idle time of labor.
11. Lack of correct or adequate accounting and production records.

Because of variations which inevitably occur, due to these and other causes, it is necessary to revise standard costs from time to time. To care for current variations in any of the factors affecting costs, variance ratios may be used, and thus permit the continued effective use of standard costs under changing cost conditions.

Determining Standard Costs.—Since manufacturing costs include the elements of labor, material, and burden, it is necessary to determine standards for each of these in order to operate a standard cost system.

STANDARD LABOR COSTS. The importance of the labor element varies with the type of industry, being of less importance when production is chiefly dependent upon machines, and vice versa. It is most subject to variation of any of the factors, and should always be watched closely.

Standard labor times are set by means of operation studies, and time cards or other records show actual times taken. Any considerable variation from standard times should be investigated and the causes disclosed. These may arise from failure to maintain the standards established following time and motion studies, incompetency on the part of the operator, or other reasons. Standard labor costs are computed by multiplying standard labor rates by standard labor times. They should be checked for individual operations, departments and for lines of products. Variations may be expressed by ratios of the actual to the standard.

Standard Material Costs. The quantities of materials needed can be very accurately determined by analysis of finished parts, experience, or test runs. The information so obtained may then be incorporated in specifications or material lists. Material requisitions for manufacture provide a check on amounts issued and used. If the records kept disclose substitution of materials, waste, or excess scrap, there is cause for inquiry. Standard material costs may be established for given periods from information furnished by the purchasing department. The major variation in material costs is likely to be in the prices paid rather than the quantities used. Inasmuch as material costs in some lines make up an important proportion of sales prices, discrepancies are important. Differences should be noted by classes of products, kinds of materials, and possibly by manufacturing departments. The data obtained can be used as a guide and check upon purchasing and sales prices. Added profits should accrue from advantageous purchases, and losses averted when market prices are high.

Standard Burden Expense. The indirect expenses of the manufacturing departments need to be cared for by a charge against manufacturing operations. These charges are made in the form of standard rates which may be applied in several ways as already described. There will inevitably be differences between manufacturing expense as incurred and the amount realized by applying standard rates. These occur because of variations from normal production schedules, and expected expense totals. The use of budgets helps in analyzing these variations and securing more effective control.

Utilizing Standard Costs.—It is important to check cost variations over periods of time. This can be accomplished by means of statistical reports or by use of graphic charts. Figure 171 shows a chart which presents in graphic form cost variations by classes of materials.

The straight lines opposite the letters denoting the classes of goods represent standard costs in dollars and cents. The solid jagged lines represent weekly records above or below that line. The dotted, irregular lines indicate last year's record against the standard. The checking of actual costs against the standard must be something more than merely a mental exercise if it is to be of value to the company.

Standard Man-Hour Cost.—A computation of the man-hour cost for work done on a particular type of machine is given in Figure 172. This summary statement indicates clearly the factors of cost which enter into the problem.

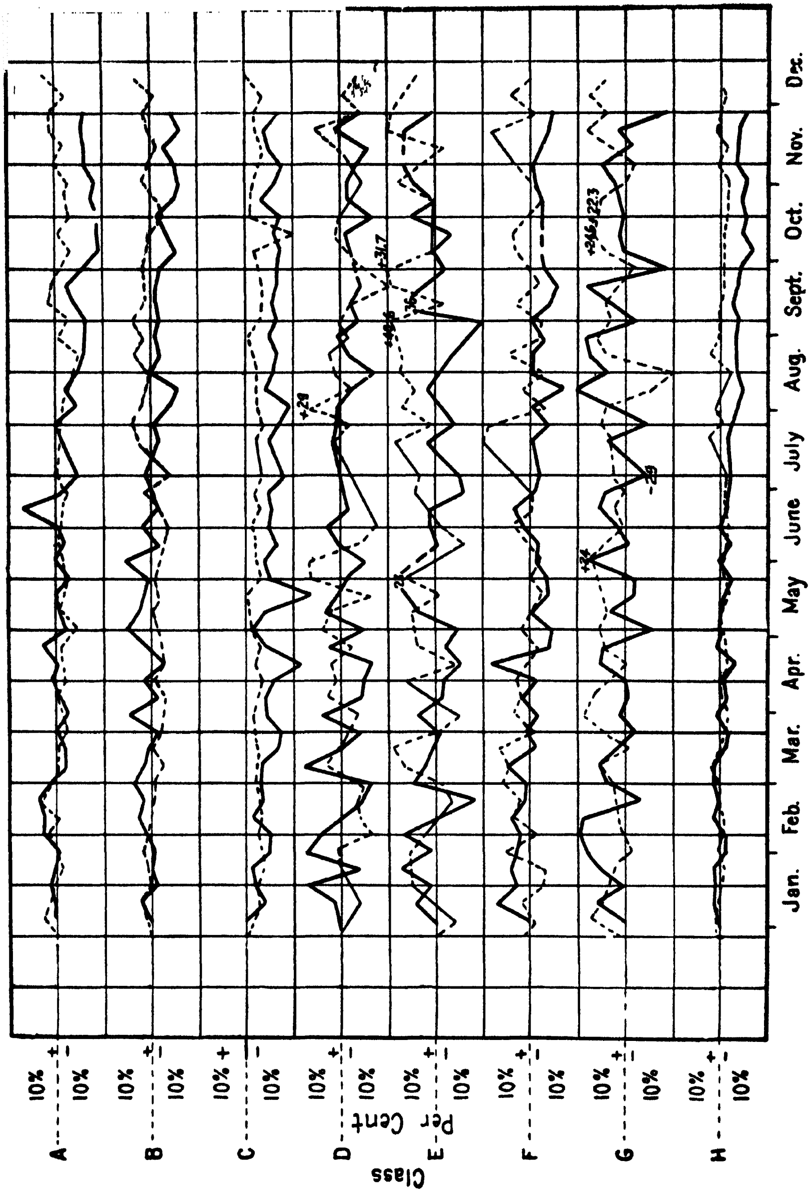


Figure 171. Chart of Standard Cost with Above and Below Variation

CODE 22 R

Standard Man Hour Cost

Redrawing Presses

One man per machine

CODE 22 R

DATE

		STD. COST PER MAN HR.	
	DIRECT LABOR		
	Productive		
	S110		
	Set-Up		
	Special Orders		
	Maintenance		
	TOTAL		.60
	CONTINGENT[1]		
	S112 Unearned Wages		.02
	S114 Overtime		.02
	S115 Samples		
	TOTAL		.0[illegible]
	INDIRECT LABOR		.30
	SUPPLIES		.0[illegible]
	MAINTENANCE OF PLANT		
	Labor		.04
2	Material		.02
	TOTAL		.05
	MAINTENANCE OF TOOLS		
	Labor		.25
	Material		.07
	TOTAL		.3[illegible]
	ROOM BUDGETED OVERHEAD		.72
	TOTAL INC. DIRECT LABOR	2	.32
	SALARIES		.05
	PAY ROLL TAX		.02
	Vacation Allowances		.0[illegible]
	DEPRECIATION		.02
	PROPERTY TAXES		.02
	POWER		.04
	STEAM		-
	RENT		.05
	TOTAL ORDINARY COSTS	2	.54
	EXTRAORDINARY[3]		
	Labor		.04
	Material		.02
	TOTAL		.06
	TOTAL ROOM COST	2	.60
	SERVICE DEPT OVERHEAD[4]		.16
	GENERAL DEPT EXPENSE		.15
	GENERAL PLANT EXPENSE[5]		.34
	ADJUSTMENT		
	GRAND TOTAL	[illegible]	.[illegible]5

NOTES

50 Machines available
Capacity one 40 hour shift: 2200 hrs.
Normal 1760 hours per week

Asset Value Depreciated	$50,000
Annual Rate 5%	
Depreciation per week	$50.00
Space. Occupied	10,000 sq.ft
Annual Cost per sq.ft	$ .45
Rent per week	$90.00
Rent per hour	$ 05

Footnotes

1 Direct labor variance.
2 Foremen held responsible for these costs.
3 Unusual repairs.
4 On repair and maintenance labor.
5 Varies according to judgment. Experience of three years immediately preceding used as guide.

Explanation of Code: Figures refer to labor grade; letter to type of operation.

Figure 172. Standard Man Hour Cost Figures for Redrawing Presses

The Operation of Cost Systems.—An effective cost system will not only give cost facts with respect to past performance, but enable those responsible for costs to control operations in prospect. Cost data must be more than history. They must point the way toward economies in operation. For this reason, in addition to accounting theory, operating experience is a prime requisite of the cost accountant or cost engineer, if he is to analyze operating conditions in preparing a cost system, and submit expense figures in proper form and sufficient detail to tell the desired story. When a manufacturing expense is incurred it is evidently for a purpose, and the cost plan will distribute all such items of expense in just proportion to the proper processes. Only by accurate allocation of expenses can individual costs be dependable and comparative; hence general accounts are to be avoided.

It is difficult to secure cost information, as such, from production departments. Operating men are primarily interested in production, and the effective administration of their departments. Cost data are best obtained, therefore, as completely as possible by means of production control and administrative forms. These include labor tickets, material and supply requisitions, output records, reports on waste, and on expense incurred for any purpose. The sources of expense should be thoroughly analyzed, as has been done in Figure 173, by the cost department of a machinery manufacturer.

- GRAND TOTAL SELLING COST OF JOB
  - A, B, C, etc. — Total Selling Cost of Worked Material by Divisions
    - Shop Cost
      - Wages
      - Expense
      - Machine Cost
      - Stores
      - Worked Material
    - Special Patterns
    - Special Tools
    - General Expense
  - Drawings
  - Stores Sold
  - Sublet Contracts
  - Freight Royalties, etc.
  - Erection

Figure 173. Chart of Costs in Connection with a Job Order

Descriptions of the individual accounts and what charges are properly made to them are a necessary part of any cost system. Examples of these are as follows:

SPECIAL TOOLS. Tools made for a special job. The selling cost of these tools is charged to the order. This includes wages, shop expense, material (stores), and general expense.

Special Patterns. Patterns made for a special job. The selling cost of these is charged to the order. This includes wages, shop expense, material (stores), and general expense.

Indirect Labor. All functional foremen, their assistants and all labor that cannot be charged to a particular manufacturing, construction, equipment, or other department order, or to one of the other expense items of this department, including machine shop tool room. Also the rate setters and route clerks in the planning department that work only for the benefit of the machine shop.

Heat, Light, and Power. Includes the labor and materials used in making steam, transmitting power, heating, light, water, etc., and also all labor and material used in repairing and maintaining the apparatus, machines, buildings, etc., in this department.

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